S-75M3-OP Volhov
(SA-2E Guideline)
Medium Range Surface to Air Missile System
Simulator Documentation



Version 3

Contents

Historical Background

In 1953, after the successful fielding the first Soviet SAM system the S-25 Berkut (SA-1 Guild), the Counsel of the Soviet Union is decided on the development of the follow-up systems.

The prohibitive cost of the fixed multichannel S-25 “Moscow” system initiated the development of two new different SAMs.

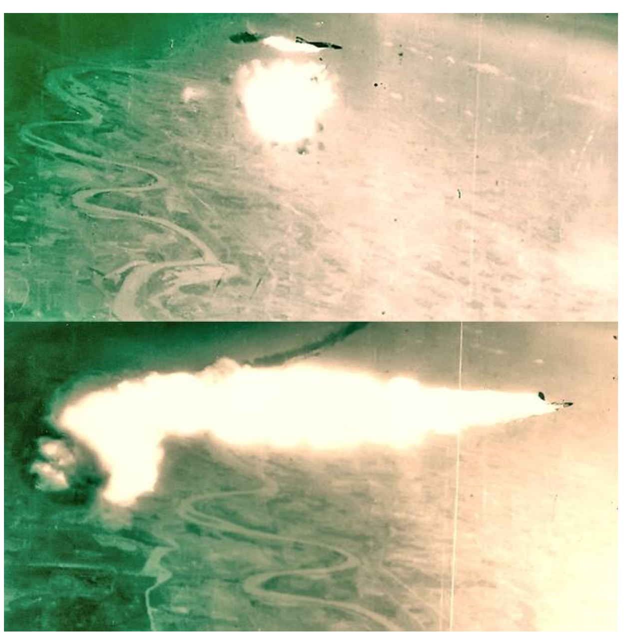
Leningrad (as the second most important city) was planned to be defended by the fixed multichannel S-50 Dal (SA-5 Griffon) system, while all the other cities by the cheaper, towed single channel S-75 (SA-2) family.

Lavochkin OKB-301 was appointed to design the fixed multichannel S-50 Dal "Leningrad" system, while the tougher task of designing a cheap - towed SAM system was given to Raspeltin’s KB-1, the successful designer of the S-25 Berkut (SA-1 Guild).

The "75" design called for a SAM system of 29km effective range, and 20km altitude, working in the 6cn frequency band. When this ran into problems, parallel development on a 10cm system was started.

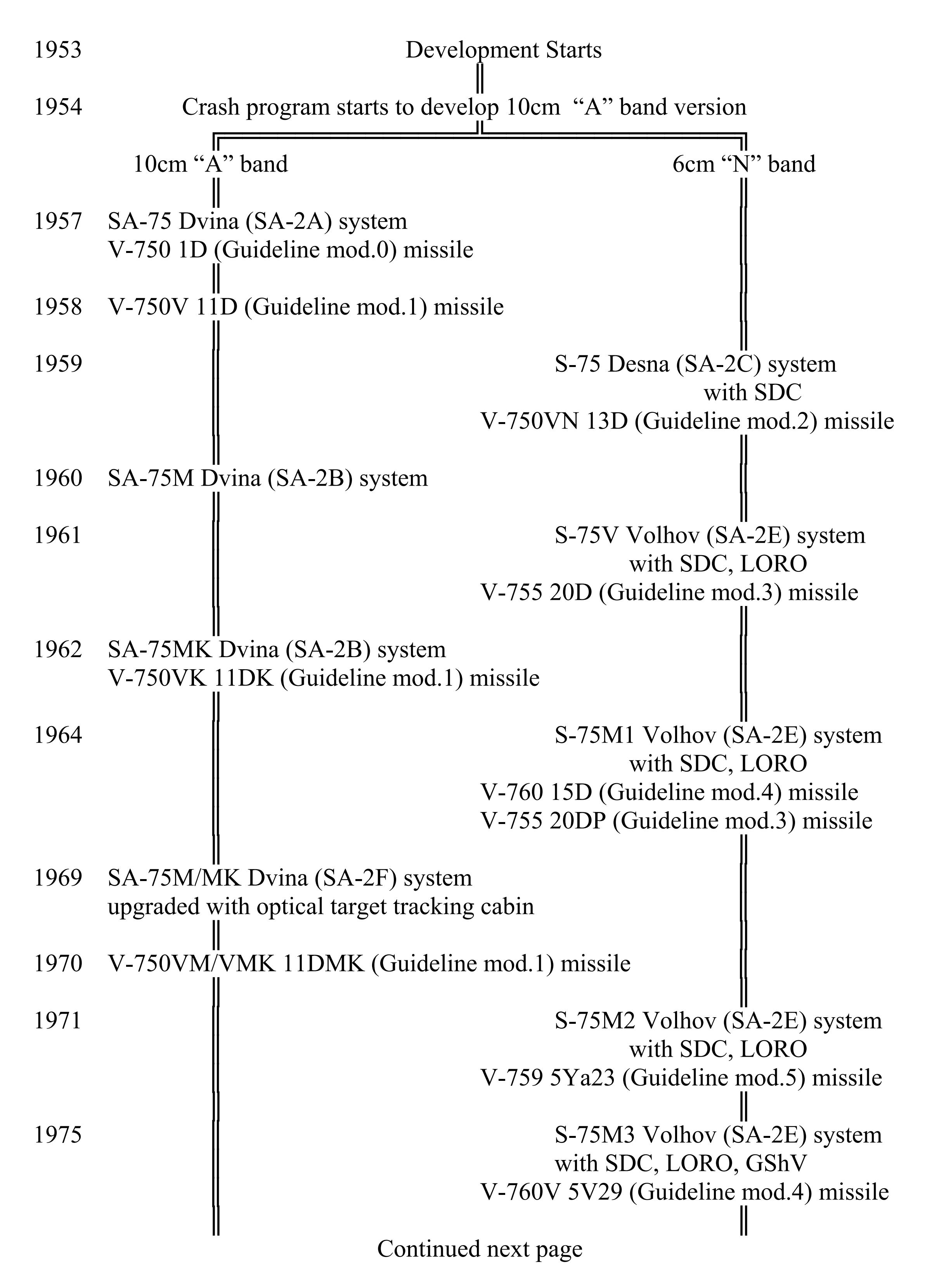


A.A. Raspeltin

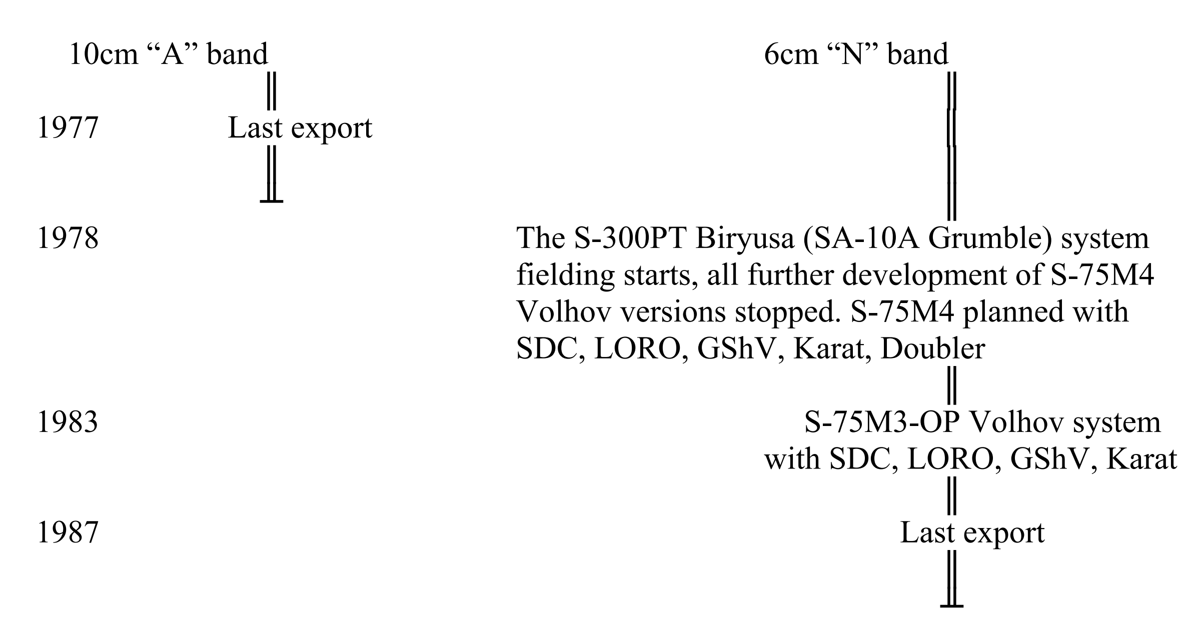


F-4 hit over Hanoi with V-750V 11D missile

The Family Tree and timeline of the "75" System development

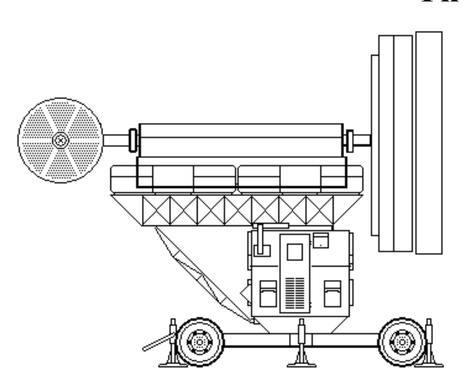


Continued next page

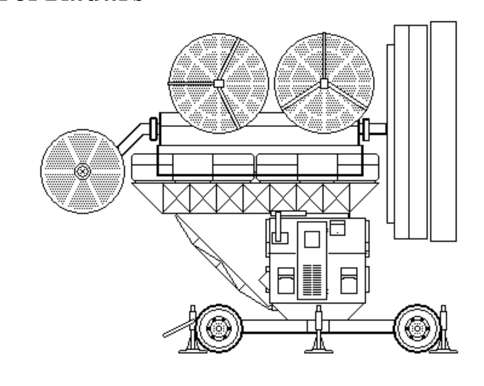


1988, The S-300PMU Volhov-M6 (SA-10B Grumble) system becomes available for export. The Volhov-M6 name was selected to confuse western intelligence.

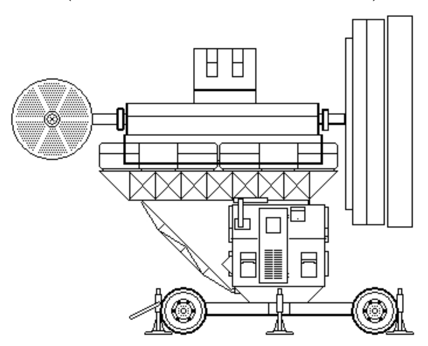
Fire Control Radars



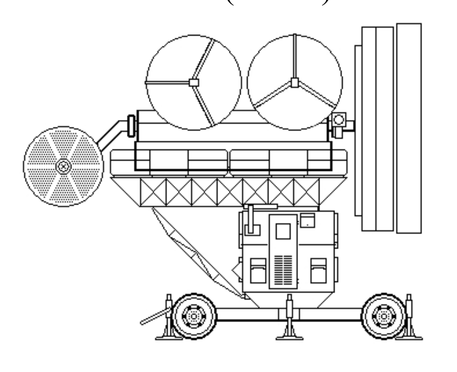
SA-75 Dvina, SA-75M/MK Dvina, S-75 Desna
(SA-2A, SA-2B, SA-2C)



S-75V/M1/M2 Volhov
(SA-2E)



SA-75M/MK Dvina
(SA-2F)



S-75M3-OP Volhov
(SA-2E)

SA-75 Dvina “five van” (SA-2A) with V-750 1D (Guideline mod.0) and 750V 11D (Guideline mod.1)

In 1954 it become clear that the new 6cm wavelength microwave parts had severe production delays. In response, a crash program was started using the old 10cm wavelength ("A" band in the Soviet Union) microwave parts of the S-25 Berkut (SA-1) system. During 1957, the first 10cm wavelength **SA-75 Dvina “five van” (SA-2A)** system was fielded in the Soviet Union. The “Five” vans were: PA – fire control radar, U – fire control cabin, I – indicator cabin, K3 – instrument cabin, (K5 – diesel generator), K6 – power distributor.

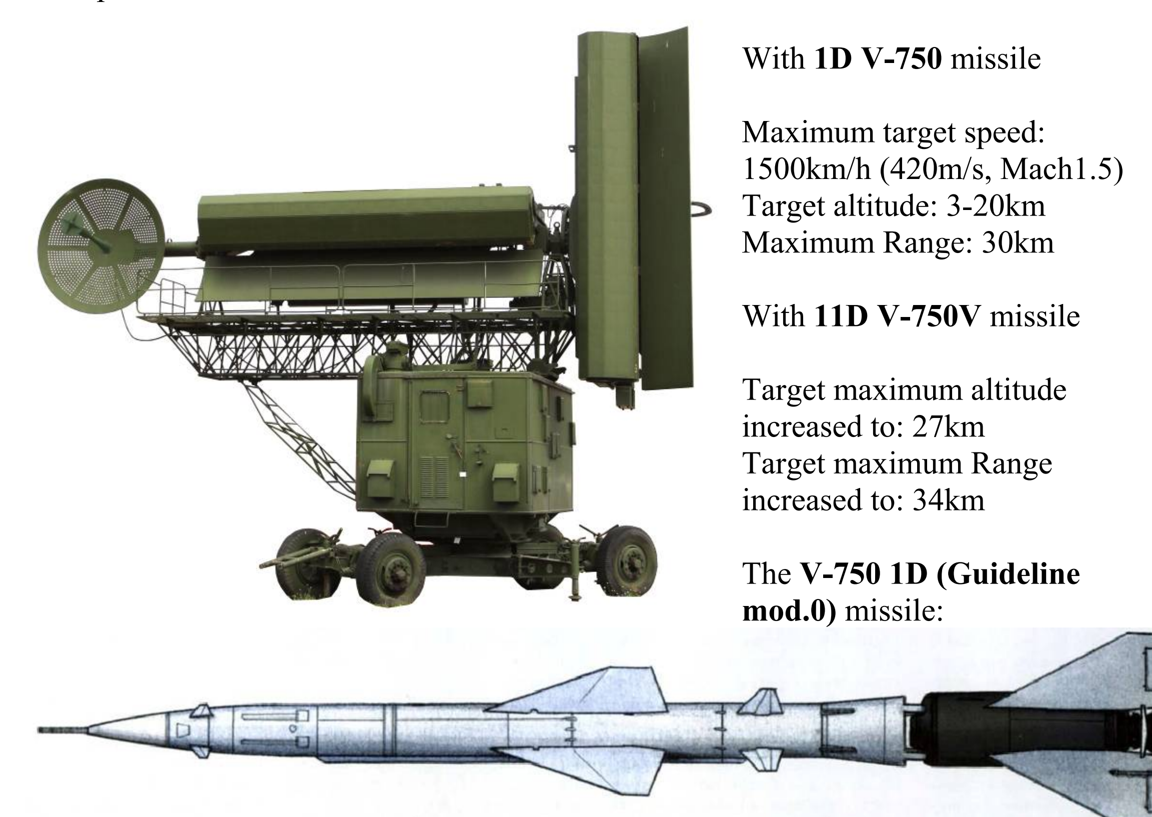
With **1D V-750** missile

Maximum target speed:
1500km/h (420m/s, Mach1.5)
Target altitude: 3-20km
Maximum Range: 30km

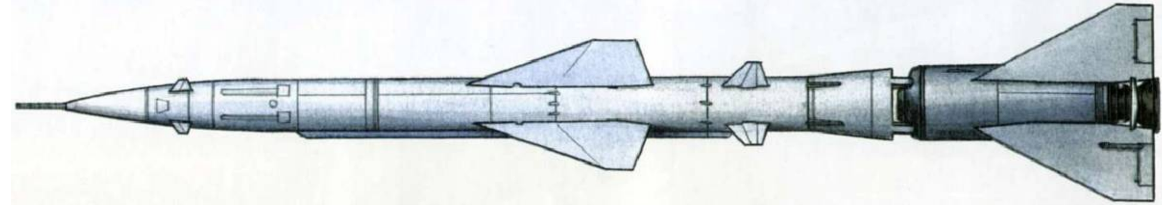
With **11D V-750V** missile

Target maximum altitude increased to: 27km
Target maximum Range increased to: 34km

The **V-750 1D (Guideline mod.0)** missile:



As the CIA's U-2 spy-plane started its regular flights over the Soviet Union only few thousand meters above the maximum effective altitude of the V-750 1D missile, again a crash program started. The thrust of the second stage was increased and the new **V-750V 11D (Guideline mod.1)** was fielded in 1958, with the increased 27km altitude capability.



This system was exported only in small numbers:
China 1958-3+1*, 1959-2
Albania, Bulgaria, Hungary, DDR, Poland, Romania, Czechoslovakia (all in 1959 1+1*)
* means training system

SA-75M Dvina “three van” (SA-2B) with V-750V 11D (Guideline mod.1)

Further optimization of the SA-75 Dvina (SA-2A) led to the reduction of the number of the towed vans. This system was called **SA-75M Dvina “three van” (SA-2B)**. The “Three” vans were for: PA – fire control radar, UA – fire control cabin, AA – instrument cabin, (RMA – power distributor, and diesel generators).

Maximum target speed was increased to: 1900km/h (520m/s, Mach1.85)

It was exported from 1960, in huge numbers with the **V-750V 11D (Guideline mod.1)** missile.

Bulgaria	1960-3, 1961-5, 1962-6
Czechoslovakia	1960-3, 1961-4, 1962-8, 1963-1*
DDR	1960-3, 1961-8, 1962-8, 1963-1*
Hungary	1960-3, 1961-4, 1962-6
Poland	1960-3, 1961-4, 1962-9+1*
Romania	1961-3, 1962-6

* means training system

SA-75MK Dvina “three van” (SA-2B) with V-750VK 11DK (Guideline mod.1)

Systems exported outside of the Warsaw Pact were marked with “K”.

Yugoslavia	1962-1+1*, 1963-2, 1964-1, 1966-1
Indonesia	1962-7+2*
North Korea	1962-2, 1966-8, 1967-4, 1970-1, 1971-18, 1973-6
India	1963-1+1*, 1964-6, 1965-5, 1966-6, 1967-1, 1969-2
Cuba	1963-24+6*
Algeria	1965-1, 1967-2
Afghanistan	1965-1*, 1966-1, 1967-2
Vietnam	1965-16+1*, 1966-18+1*, 1967-42+2*, 1968-4, 1969-2, 1972-12
Egypt	1965-18+2*, 1966-9, 1967-2, 1969-8, 1970-10, 1971-3
Syria	1968-2, 1969-4+1*
Sudan	1969-1*, 1973-3
Somalia	1973-3, 1976-4
Yemen	1977-4

* means training system

S-75 Desna (SA-2C) with V-750VN 13D (Guideline mod.2)

The definitive version of the "75" design, the 6cm wavelength ("N" band in Russia) **S-75 Desna (SA-2C)** was fielded in the Soviet Union from 1959, with the **V-750VN 13D (Guideline mod.2)** missile. The name of the vans changed: P – fire control radar, U – fire control cabin, A – instrument cabin, (R – power distributor, and diesel generators).

This system introduced the SDC (Moving Target Indicator), making it capable of tracking low flying targets against ground clutter.

Maximum target speed: 1900km/h (520m/s, Mach1.85)
Target altitude: 500m-24km
Maximum Range: 34km

On the 1st of May, 1960, a U-2 spy plane was successfully engaged by an S-75 Desna (SA-2C) SAM system over Sverdlovsk utilizing a V-750VN 13D (Guideline mod.2) missile.

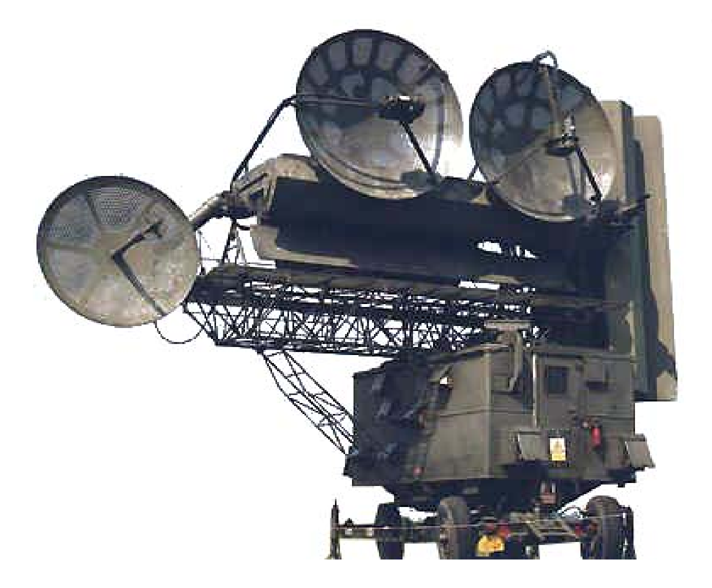

Pieces of the U-2 spy plane in Moscow shot down by the S-75 Desna (SA-2C).

This version was only exported to Egypt, but in large numbers.

Egypt 1970-20, 1971-12

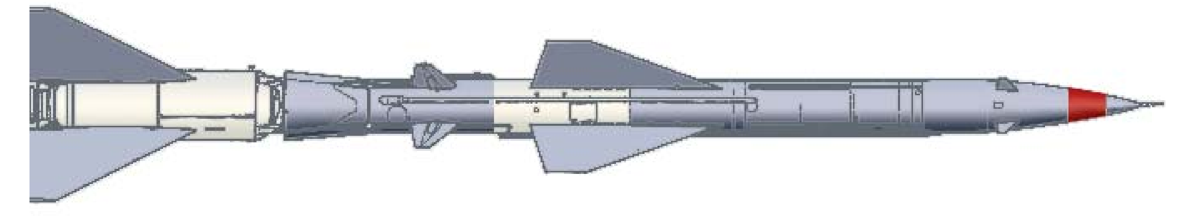
S-75V Volhov (SA-2E) with V-755 20D (Guideline mod.3)

In 1961, the last major version, of the "75" system was fielded with SDC (Moving Target Indicator), for tracking low flying targets against ground clutter, and LORO (Lobe On Receive Only), that tripled the density of the target tracking microwave energy in a given airspace. Again the name of the vans changed: PV – fire control radar, UV – fire control cabin, AV – instrument cabin, (RV – power distributor, and diesel generators).



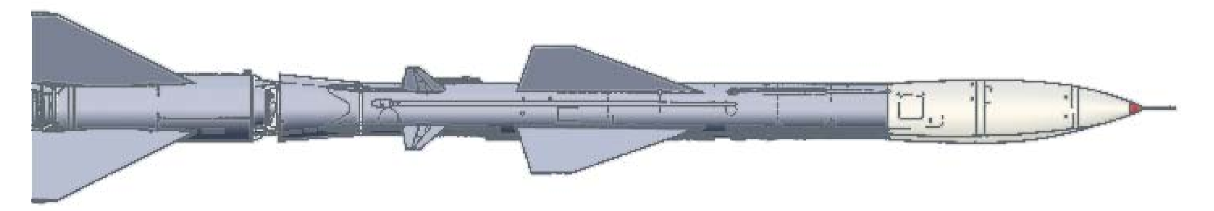
Maximum target speed:
2300km/h (640m/s, Mach2.3)
Target altitude: 3-30km
Maximum Range: 43km

The **V-755 20D (Guideline mod.3).**



S-75M1 Volhov (SA-2E) with V-755 20DP (Guideline mod.3) and V-760 15D (Guideline mod.4)

In 1964, the next Volhov version, introduced the nuclear tipped **V-760 15D (Guideline mod.4)** missile, with 15kt nuclear warhead, and the RD-75 Amazonka range-only radar.



With the improved **V-755 20DP (Guideline mod.3)** missile, maximum range was extended to 55km against subsonic targets.

SA-75M Dvina "doghouse" (SA-2F) with V-750VM/VMK 11DM/DMK (Guideline mod.1)

During the Vietnam War, the Soviet Union rejected the transfer of the more advanced S-75M Volhov (SA-2E) system to the warzone, in the fear of getting it compromised. Instead from 1969, they exported an upgrade kit, containing several internal advances and the capability for manual optical target tracking from the "doghouse" cabin located on the top of the antenna. Eventually all exported basic **SA-75M Dvina (SA-2B)** systems received this upgrade, with the improved **V-750VM/VMK 11DM/DMK (Guideline mod.1)** missile.



With **11DM/DMK V-750VM/VMK** missile:

Maximum target speed was increased to: 3600km/h (1000m/s, Mach3.6)
Target minimum altitude was decreased to: 100m

Earlier **11D/DK V-750V/VK** missiles could also be used.

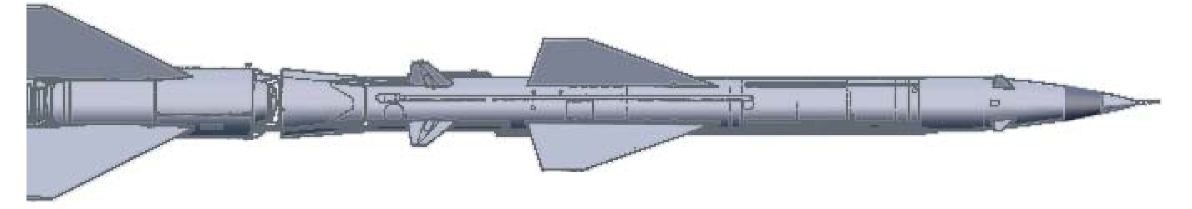




12/26/1972, B-52D "Ebony-02" disintegrates over Hanoi.

S-75M2 Volhov (SA-2E) with V-759 5Ya23 (Guideline mod.5)

In 1971, the next Volhov version was introduced, the **V-759 5Ya23 (Guideline mod.5)** missile with improved maneuverability.



All earlier 20D/15D versions could also be used.

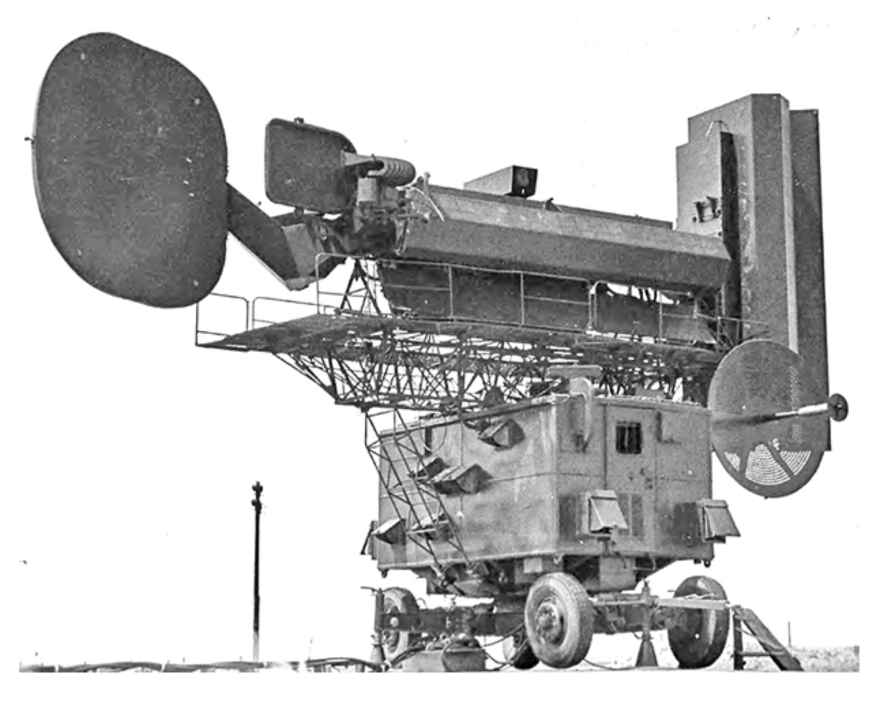
S-75M3 Volhov (SA-2E) with V-760V 5V29 (Guideline mod.4)

In 1975, the next Volhov version, introduced the GShV (Angle Deception Jamming Canceller) circuit, and the improved **V-760V 5V29 (Guideline mod.4)** nuclear tipped missile, that was based on the V-759 design.

All earlier 20D/15D/5Ya23 missile versions could also be used.

S-75M4 Volhov

During November of 1978, testing was finished of the next Volhov version.
It introduced the 9Sh33A "Karat" target tracking TV camera, a new narrow beam antenna system, capable of tracking low altitude small radar cross section targets, and the "Doubler" equipment to confuse Anti Radiation Missiles with a false emitter.



During 1978, the S-300PT Biryusa (SA-10A Grumble) system fielding started. All further development work on the S-75M4 was immediately stopped, but the advancements developed were made available as an upgrade package to earlier S-75 variants.

S-75M3-OP Volhov (SA-2E)

From 1983 an upgrade package made from the advances of the S-75M4 system become available. It introduced the 9Sh33A "Karat" target tracking TV camera.

The S-75M* Volhov (SA-2E) system exports

It is important to note, that during planned 5 year maintenance (overhaul), the older versions received the advances of the newer systems, so in theory all Volhovs were at the S-75M3-OP level after the middle of the 80's.

Czechoslovakia 1964-3, 1965-6, 1971-2, 1976-2, 1983-1, 1984-2, 1985-2
DDR 1964-4, 1965-4, 1970-4, 1971-1, 1972-4, 1974-2, 1975-2, 1976-6, 1977-2, 1983-1
Poland 1964-10, 1967-1, 1968-3, 1969-5, 1970-5, 1971-1, 1973-1, 1975-1
Romania 1964-4, 1965-2, 1968-1, 1975-1, 1976-1, 1977-1, 1978-1, 1982-2, 1983-3, 1984-3, 1985-4, 1986-4
Mongolia 1964-1, 1970-1

Yugoslavia 1966-2, 1967-2, 1970-1

Bulgaria 1969-2, 1970-1, 1974-1, 1981-1, 1983-1, 1985-4

Egypt 1973-8
Syria 1973-6, 1974-4, 1975-3, 1977-9, 1978-3, 1979-6, 1980-1, 1981-3, 1982-7, 1983-6, 1987-5
Iraq 1974-4, 1975-3, 1976-4, 1977-4, 1979-2, 1980-4, 1981-4, 1984-3, 1985-3, 1986-4
Libya 1975-12, 1977-2, 1978-8, 1979-4, 1982-6, 1984-3, 1985-4

Hungary 1977-1, 1978-4, 1982-2, 1983-3, 1984-3

Ethiopia 1978-4, 1985-3
Vietnam 1979-8, 1980-3, 1982-3, 1985-4, 1986-8, 1987-10
Yemen 1980-3, 1981-9, 1983-3, 1987-3
Cuba 1981-3, 1983-3, 1984-5, 1985-3, 1987-4

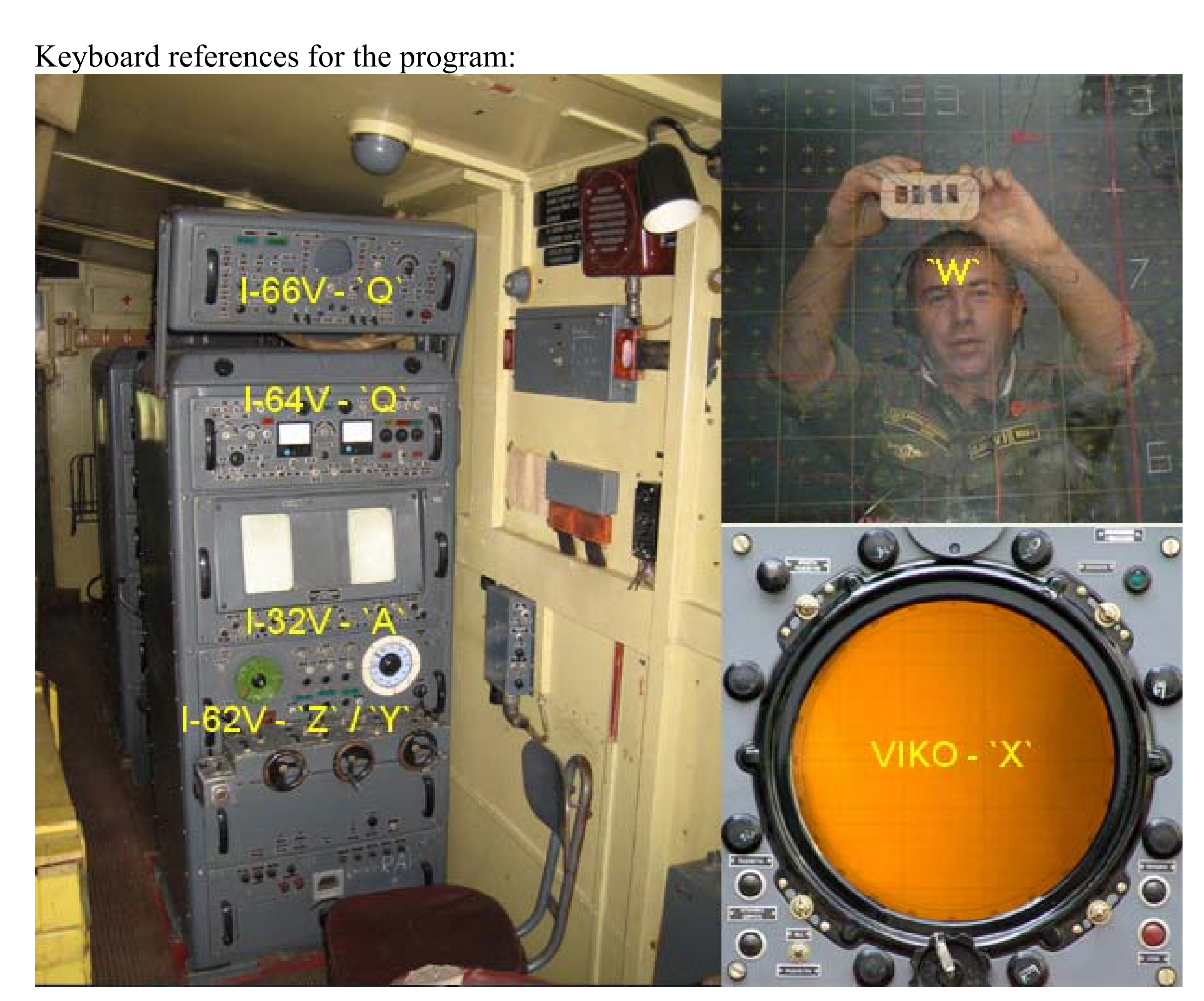
Angola 1984-3, 1987-4
Mozambique 1986-3
North Korea 1986-3

These numbers include training systems also.

During its service, the “75” SAM system was more effective than any contemporary Soviet fighter type. Among the SA-2’s achievements are shooting down Francis Gary Power’s U-2, killing fifteen B-52s during the Linebacker II raids on North Vietnam and downing scores of fighters over the Middle East, Southern and Southeast Asia.
The SA-2 was constantly improved during its lifetime (SA-2A ... F), and this was reflected in the types of targets used for practice shooting at Asuluk in the Soviet Union.
- From 1962 the target was an F-86 Sabre imitator.
- From 1968, high speed high altitude target was introduced (H>16km, V>Mach2).
- From 1972, low altitude target was introduced (H<100m).
- From 1983, cruise missile target was introduced.
- From 1989, target imitating Stealth aircraft was introduced in Asuluk.

This program simulates the most advanced version, the S-75M3-OP Volhov (SA-2E Guideline).

Keyboard references for the program:



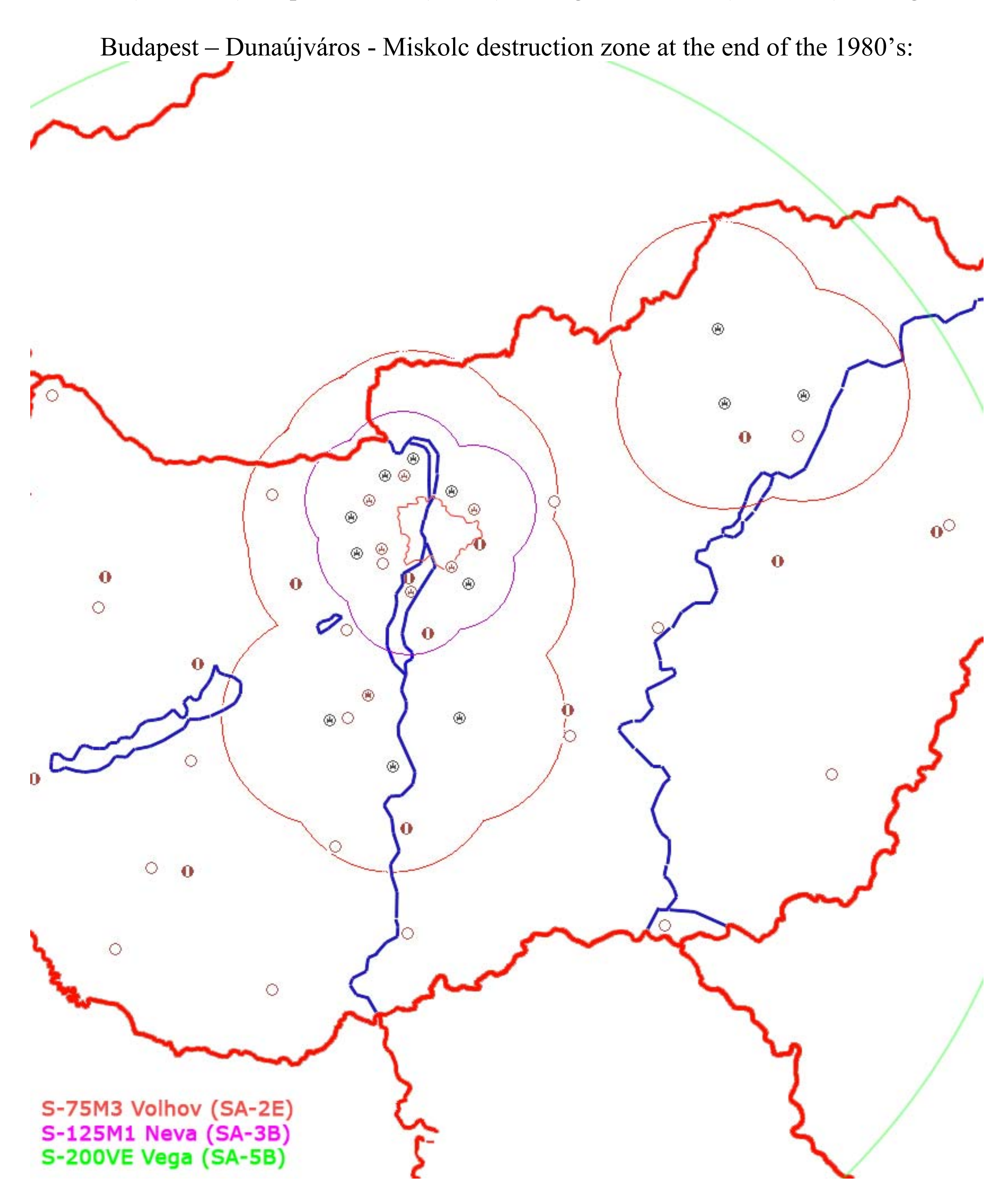
Requirement to run this program

Computer must be able to display resolution 1280x1024 or above.

Engagement zone

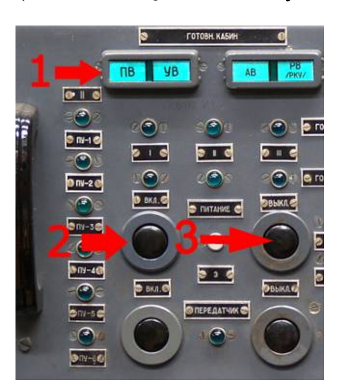
The S-75M3-OP has one target and three missile channels, meaning that it can track one target, and guide three missiles onto it. The maximum flight parameters of the target are 1000m/s (Mach 3.5) in speed, 55km (30 nm) in range, and 35km (115,000ft) in height.

Budapest – Dunaújváros - Miskolc destruction zone at the end of the 1980's:



Switching Simulator on-off

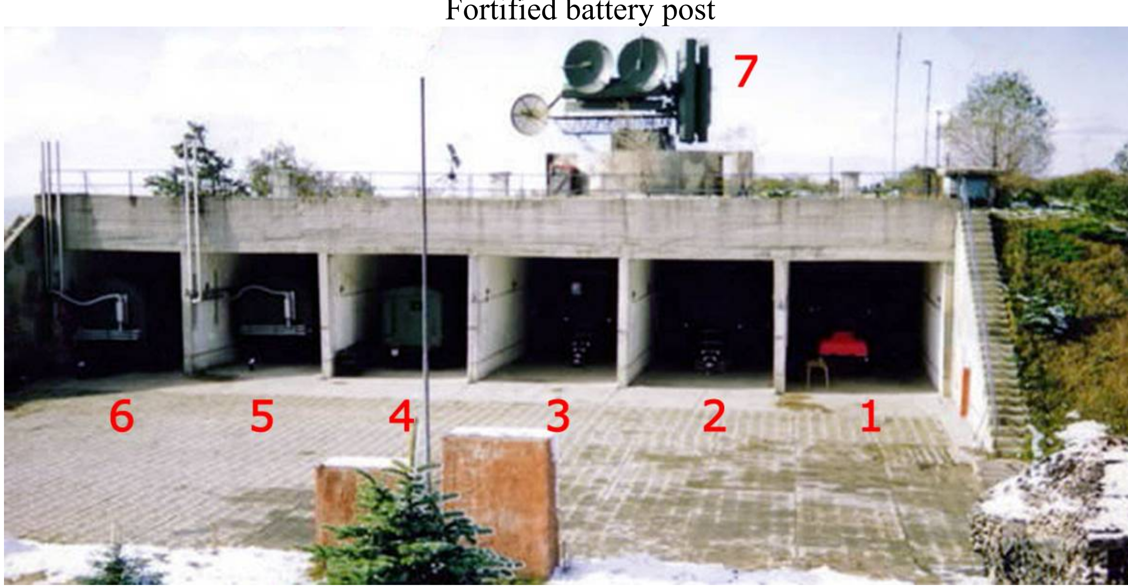
(Press the “Q” button on your keyboard to call up the I-66V/I-64 panel)



If all four subsystems are ready for action (as indicated by green lamps - 1), then the system can be started by pressing switch (2). To turn off the simulation, push button (3).

ПВ – PV, is the RSN-75V3 (Fan Song E) fire control radar
УВ – UV, fire control cabin (where we sit)
АВ – AV instrument cabin (analogue computer)
РВ /рку/ - RKU-V power distributor cabin

Fortified battery post



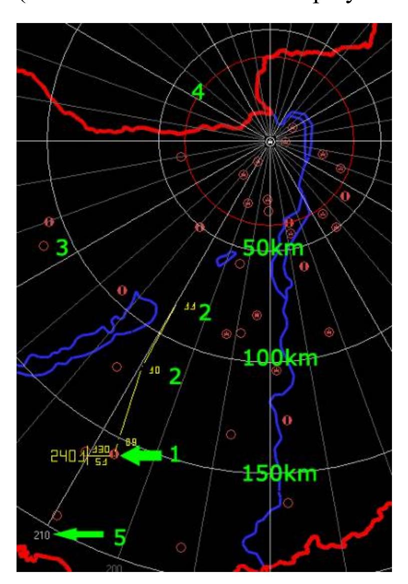
1. 5F24 integrated air defense system interface cabin and a 250 kg [550 lb] towed fire extinguisher.
2. UV fire control cabin, where we sit (battery commander, fire control officer, tracking operators, plotting table writer, launcher system operator)
3. AV instrument cabin (analog computer)
4. ZEF cabin (IFF system ‘NRZ’), PRM-V cabin (spare part stock)
5. 2pcs 5E96 cabin (Each with two 100kW diesel generator)
6. 1pcs 5E96 cabin (With two 100kW diesel generator), RKU-V power distributor cabin (allowing the system to feed from the generators or from the national power grid)
7. PV cabin, RSN-75V3 (Fan Song E) fire control radar

Methods of target acquisition

There are four possible methods of target acquisition:
- From the plotting table. This was used since the first fielding of the system and was developed by the British during the World War II.
- From the battery's early warning radars (P-12/18 Spoon Rest, P-15 Flat Face). These were introduced in 1962 and made the battery capable of autonomous target detection.
- From the integrated air defense system was fielded from 1980 in Hungary.
- From the SNR-75 (Fan Song) radar using elliptical search

Plotting Board

(Push the "W" button to display the Plotting Board)



Target parameters, detected by radar battalions (red circles in the table - 3) are written on the glass plotting board.

Target parameters (1) :

2401 | 130 / 51

2401 (Tall numbers) – target number

24 – Tactical number of the radar battery, detected the target first

01 – Sequential number of the target, detected by the same radar battery

130 (numerator) – Target height in hectometers (130x100=13,000m or 43,000ft)

51 (denominator) – type of the target (friendly – *1pcs*)

(tens digit)

0 – jamming target
1 – friendly target
2 – identified target
3 – border violator
4 – supervisor target
5 – own target
6 – rule violator target
7 – practice target
8 – enemy
9 – target without IFF

(ones digit)

Number of the targets in the formation (1pcs)

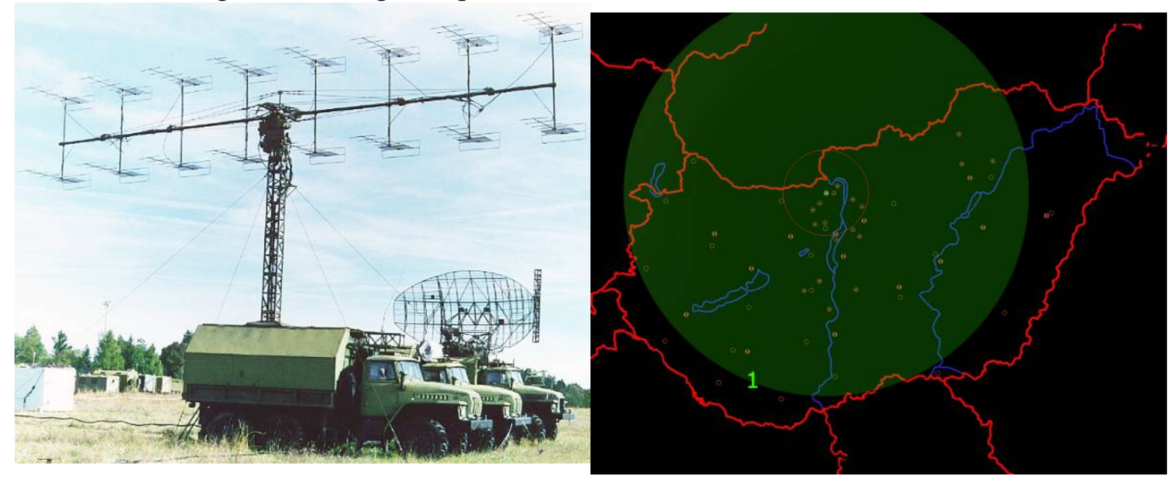
The location of the target (2) is updated every minute, and a timestamp is noted (9, 10, 11, …). In the plotting table, the destruction zone of the battery is marked by a red circle (4). White circles are marking the range from the battery (50-100-150-200km). The target direction can be read from the radial lines, (thin line every 10°, bold line every 30°).

Target data read from the plotting board, above: At time 11, one own plane, direction 210°, range 80km, height 13km.

P-18 (Spoon Rest-D) target acquisition radar

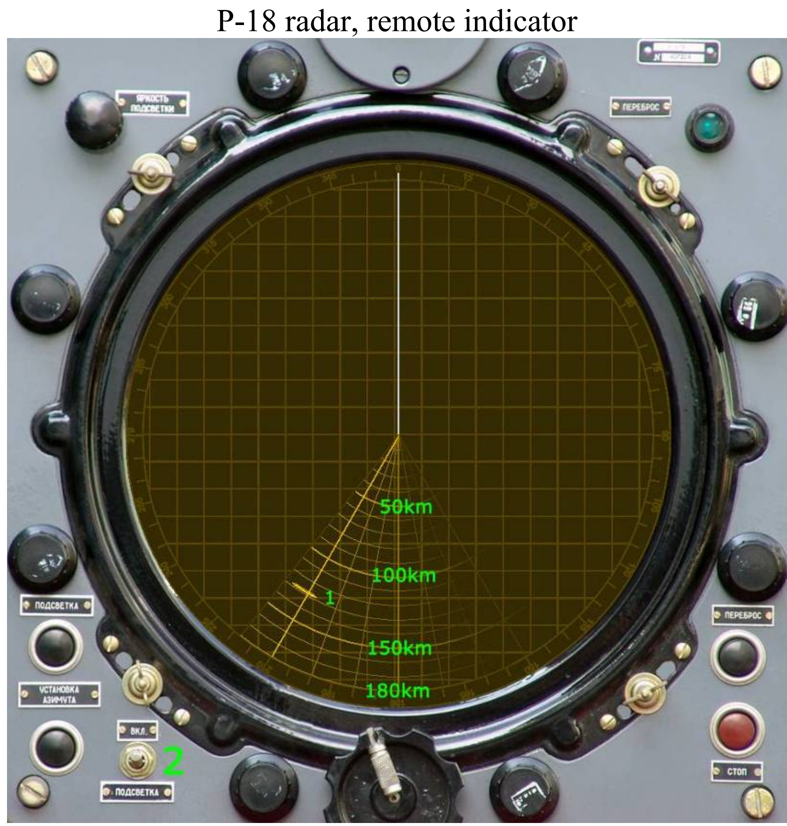
(Push the "X" button to display the P-18's scope)

Metric wavelength, P-18 target acquisition radar.



The VHF band target acquisition radar detection range is 180km for fighter sized targets (1).

P-18 radar, remote indicator



1. *Target at 212°, 129km distance*
2. Switch to turn off the adjustment raster

Clicking into the scope area, with left or right mouse button will change its displayed range between 90-180-360km.

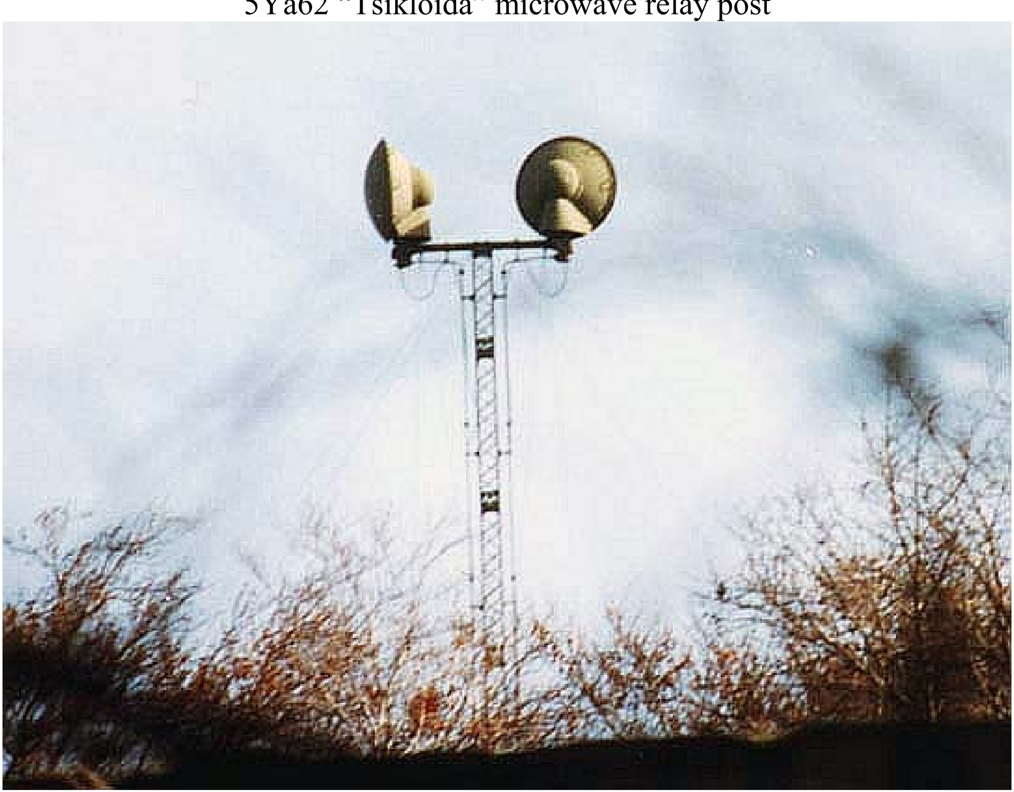
Vector-2VE/Senezh-ME, Integrated Air Defense System (IADS)

IADS function is to automate pairing of targets with engagement weapons (fighters or SAMs). It uses information from radar battalions and a data link to transmit the designated target's location to the SAM battalion every once every 10 seconds. The SAM battery has two connections to the IADS:

- The main connection is by ground cable
- The backup connection is by the 5Ya62, 5Ya63 "Tsikloida" (microwave relay)

The IADS interface to the SAM battery is the 5F24 cabin.

5Ya62 "Tsikloida" microwave relay post



Vector-2VE

Fielded in 1980, at the fortified base "20", near the city of Érd.
Capable of directing …

14 SAM batterys (SA-2 Guideline, SA-3 Goa)
6 fighter formations (MiG-21 Fishbed, MiG-23 Flogger)

… automatically, against 40 hostile targets simultaneously.

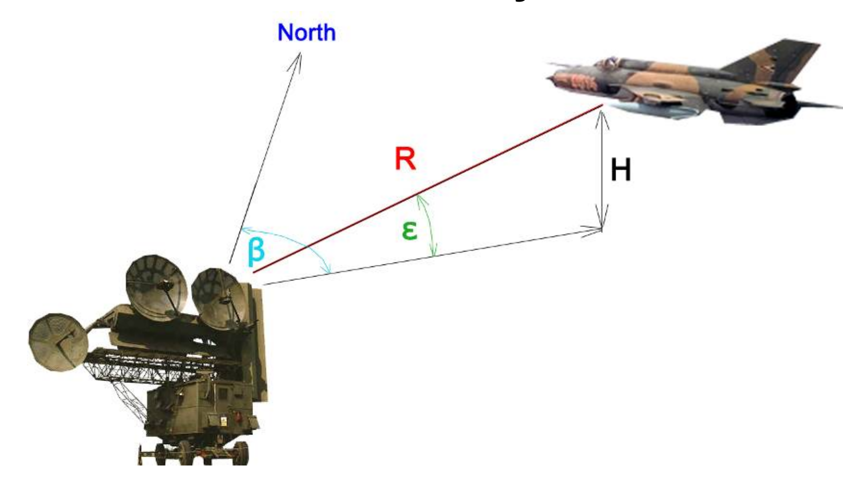
Senezh-ME

Fielded at Szarvaspuszta, during 1988, at the fortified base "50".
Capable of directing…

17 SAM batterys (SA-2 Guideline, SA-3 Goa, SA-5 Gammon, SA-10 Grumble), altogether 24 target channel
MiG-21, MiG-23, MiG-25 fighter formations

… automatically, against 50 hostile targets simultaneously.

Parametric coordinate system

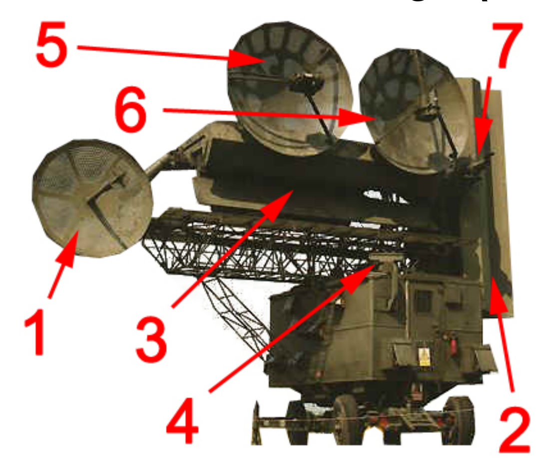


R – target range
H – target height
ε (epsilon) – elevation (antenna up - down)
β (beta) – azimuth (antenna left - right)

RSN-75V3-OP (Fan Song E) fire control radar

Built since 1975, Hungary fielded from 1983.

RSN-75V3-OP Fan Song E (P3V cabin) in detail



1. P-16: dm wavelength, missile command transmitter antenna.
2. P-12V: 6cm wavelength, wide beam, elevation (ε - epsilon) antenna.
3. P11V: 6cm wavelength, wide beam, azimuth (β - beta) antenna.
4. Azimuth dummy antenna. The elevation dummy antenna is at the back of the cabin.
5. P-14V: 6cm wavelength, narrow beam, elevation (ε - epsilon) antenna.
6. P13V: 6cm wavelength, wide beam, azimuth (β - beta) antenna.
7. 9Sh33A camera. (optical channel)

Switching on the RSN-75V3 Fan Song E

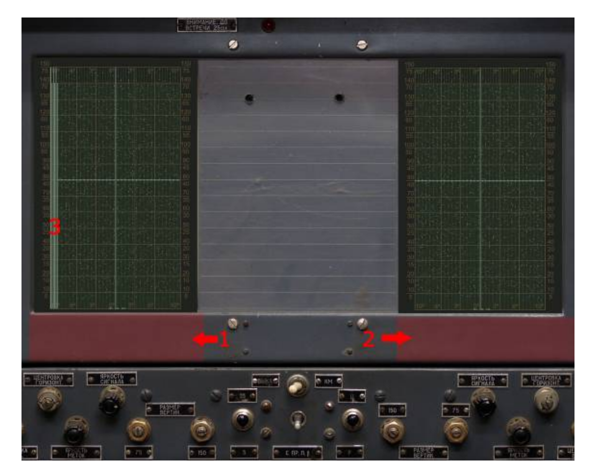
(Push the "Q" button)



1. Transmitter on
2. Switching between antenna and dummy load. (Antenna - up / dummy – down)
3. Transmitter off, receiving only. (used to track noise jamming targets)

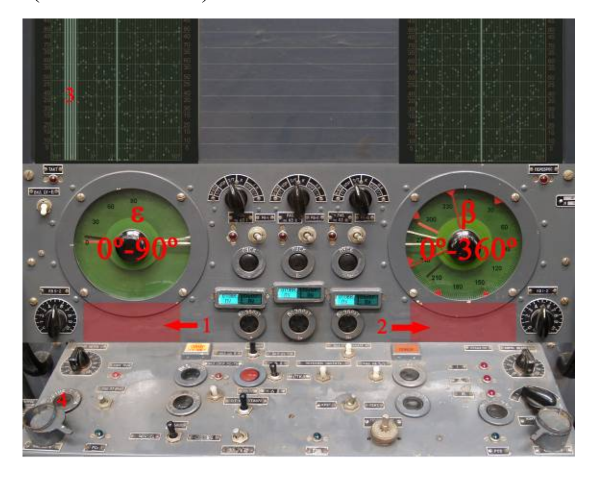
Rotating the RSN-75V3 Fan Song E

(A - button)



The left indicator is for the epsilon (elevation) plane, the right is for the beta (azimuth) plane.
Holding down the left mouse button in the red area (1), and moving it to right-left, we can rotate the PV in the ε plane (up-down).
(3) reflection from the ground.
Holding down the left mouse button in the red area (2), and moving it to right-left, we can rotate the PV in the β plane (right-left).

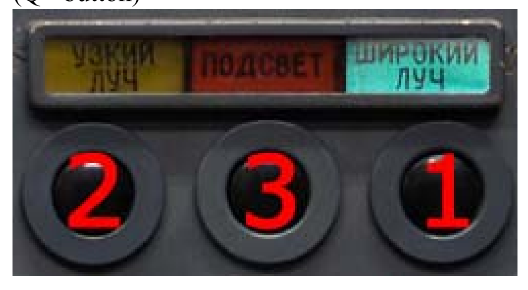
(Z or Y - button)



The green round instruments below the indicators show the PV's current orientation. Black pointers show the direction of the PV, while red pointers show the direction of the missile launcher. Red triangles show the directions of the launchers relative from the PV. If we lower the antenna below zero (ε<0°), it will jam down, and cannot be raised. In this case, we need to push the jam release button (4), before we can raise it again.

RSN-75V3 Fan Song E mode of operations

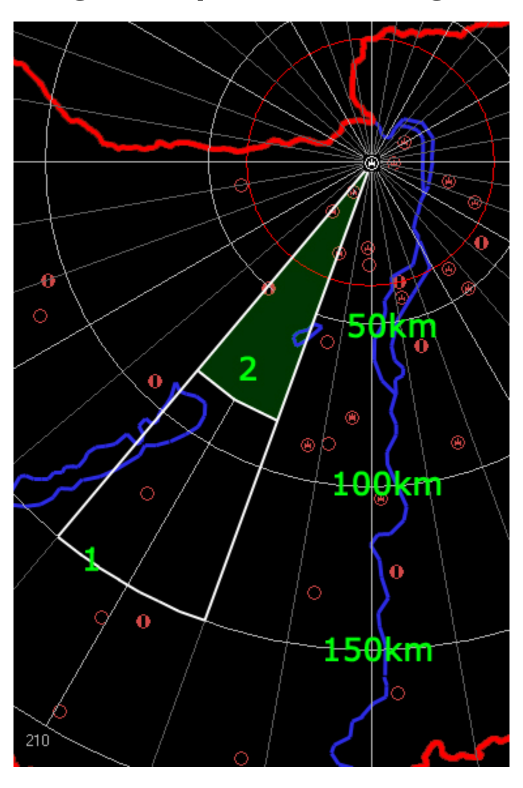
(Q - button)



1, Wide beam mode
2, Narrow beam mode*
3, LORO (lobe on receive only) mode*

* Dummy load cannot be used with these modes, the antenna/dummy load switch must be in “antenna.”

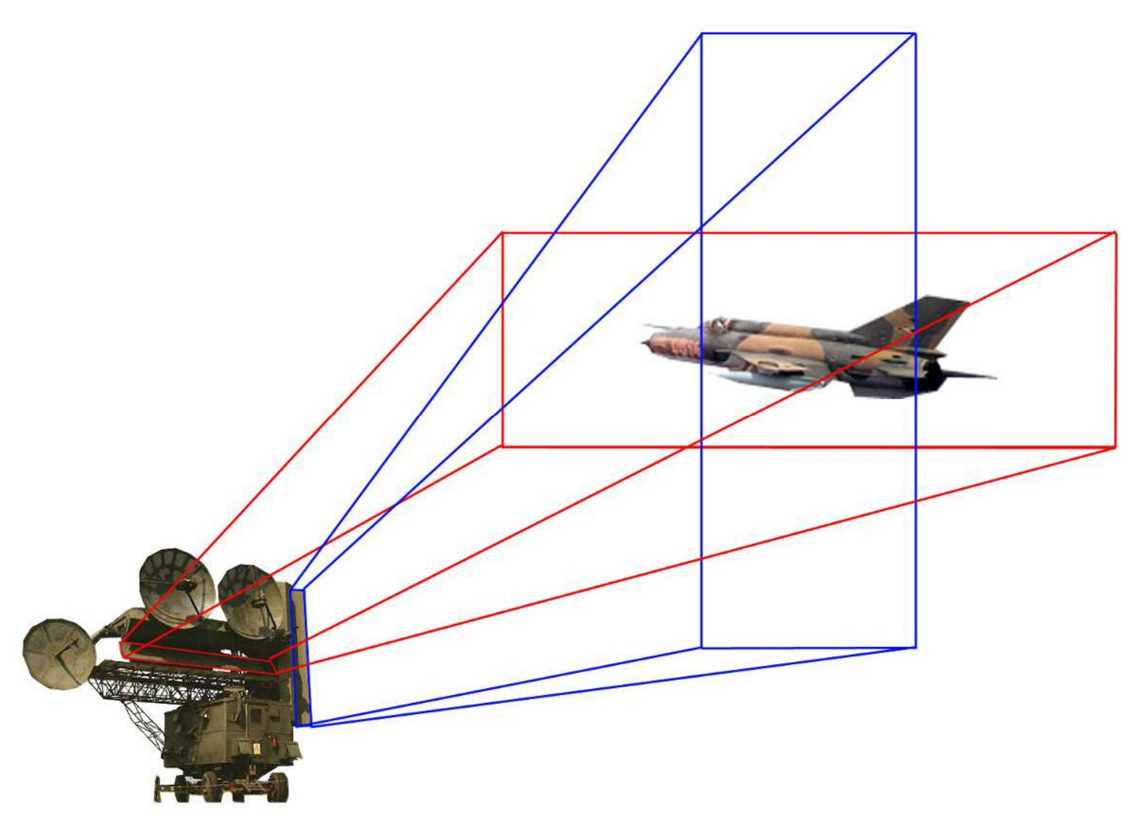
Target Acquisition using Wide Beam mode



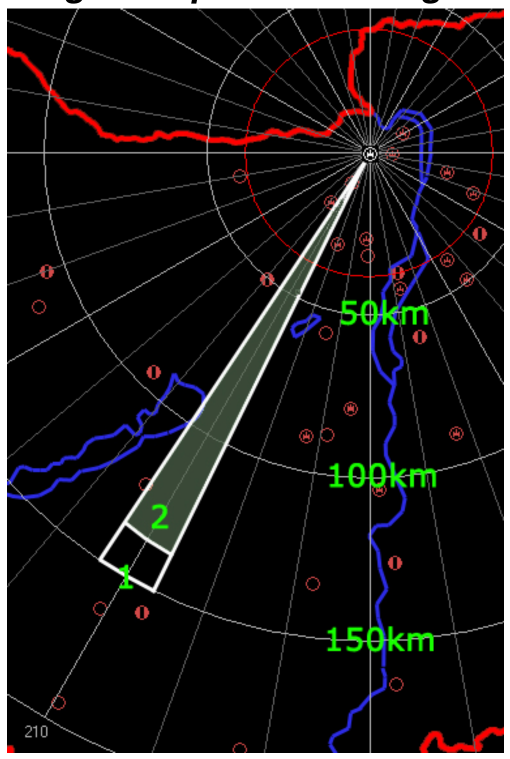
Wide Beam mode should be used:
- if the target is flying at low altitude (H<5,000m)
- if we shoot at a ground target
- if usage of ARM is expected (Anti Radiation Missile – Shrike, HARM)
- with plotting table acquisition.

1. The 20º wide beam detection range, for a bomber sized target is 150km.
2. Detection range for a fighter sized target is around 80km.

Radar returns from the target and missiles are received by:
- (ε - epsilon) elevation: P-12V wide beam antenna
- (β - beta) azimuth: P11V wide beam antenna



Target Acquisition using Narrow Beam mode

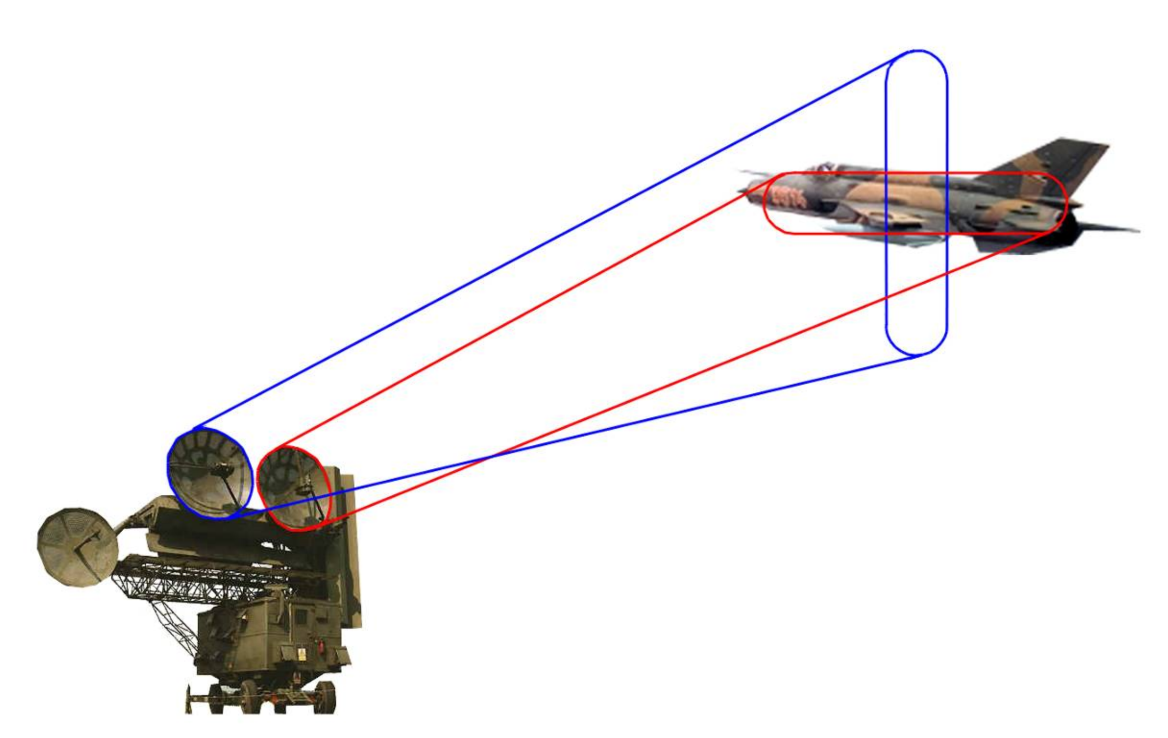


Narrow Beam mode should be used:
- When the target range is over 70km
- With P-18 or IADS target acquisition

1. the 7.5º narrow beam detection range, for a bomber sized target is 150km.
2. detection range for a fighter sized target is around 130km.

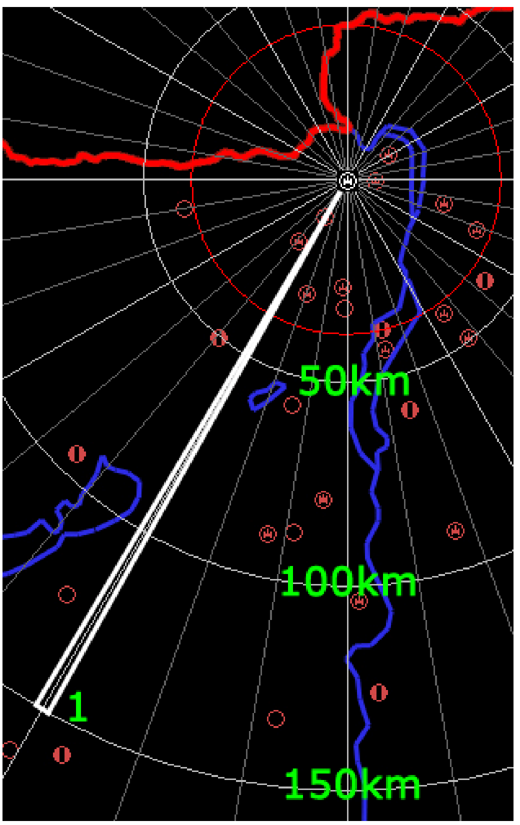
Radar returns from the target are received by:
- (ε - epsilon) elevation: P-14V narrow beam antenna
- (β - beta) azimuth: P13V narrow beam antenna

Radar returns from the missiles are received by*:
- (ε - epsilon) elevation: P-12V wide beam antenna
- (β - beta) azimuth: P11V wide beam antenna



*In Narrow Beam mode, **successful missiles guidance is NOT GUARANTEED**, as the returns from the missiles and target are received by different antenna pairs. The last 25 seconds before missile impact, the Fan Song E should be switched to LORO mode!

Target Tracking using LORO (lobe on receive only) mode

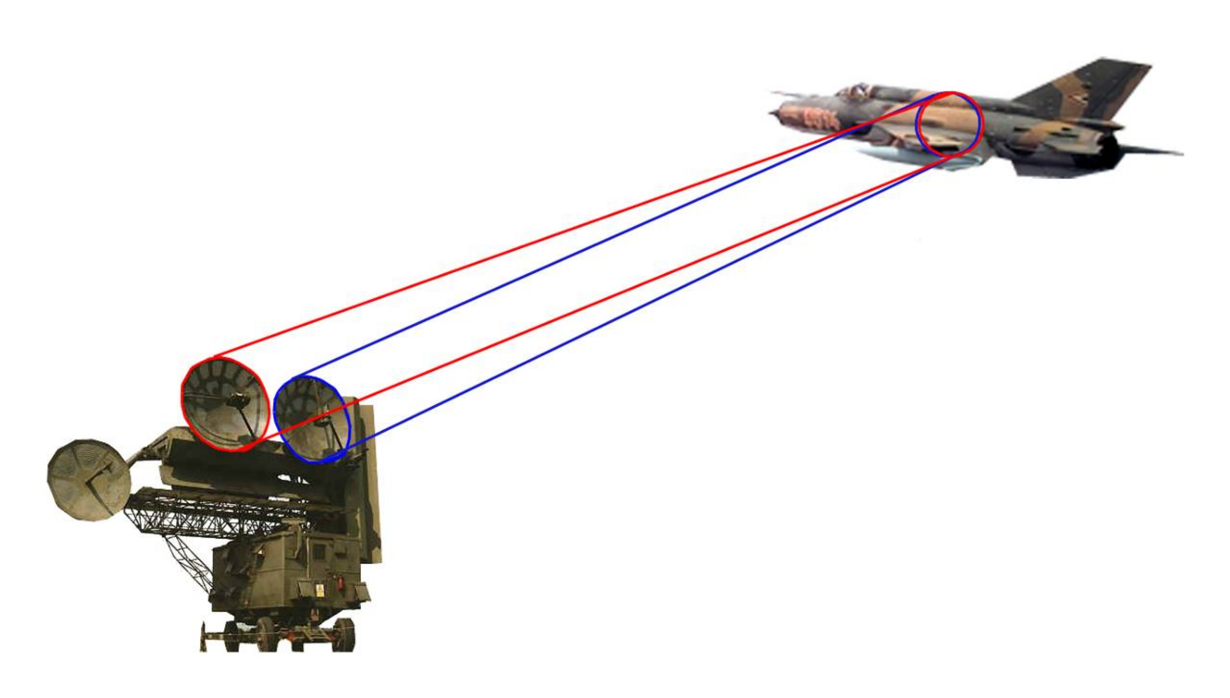


After successful target acquisition in narrow beam mode, we switch to LORO mode for target tracking.

In LORO mode, only the target could be detected by the 1.7º pencil beam (1).

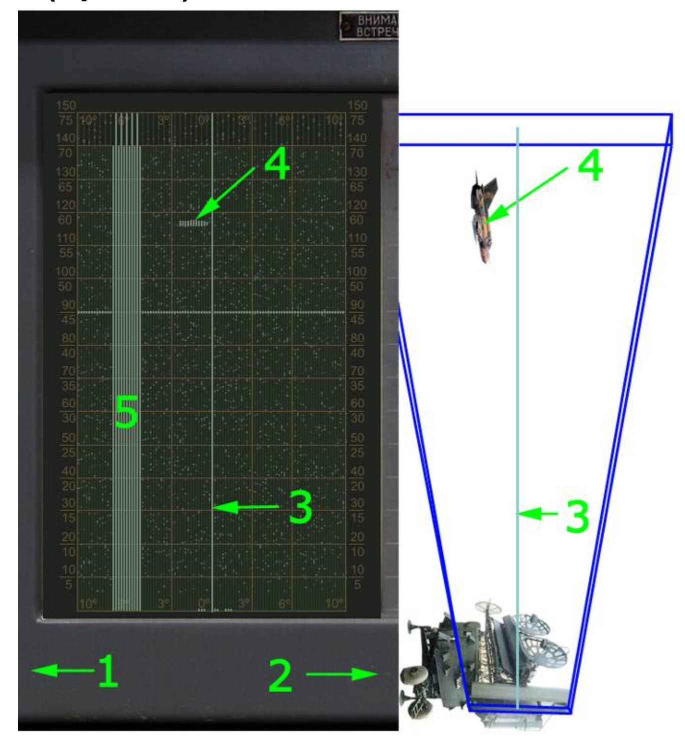
Transmit:
- (ε - epsilon) elevation: P-14V narrow beam antenna
- (β - beta) azimuth: P13V narrow beam antenna

Radar returns from the target and missiles are received by:
- (ε - epsilon) elevation: P-12V wide beam antenna
- (β - beta) azimuth: P11V wide beam antenna



Understanding the indicators

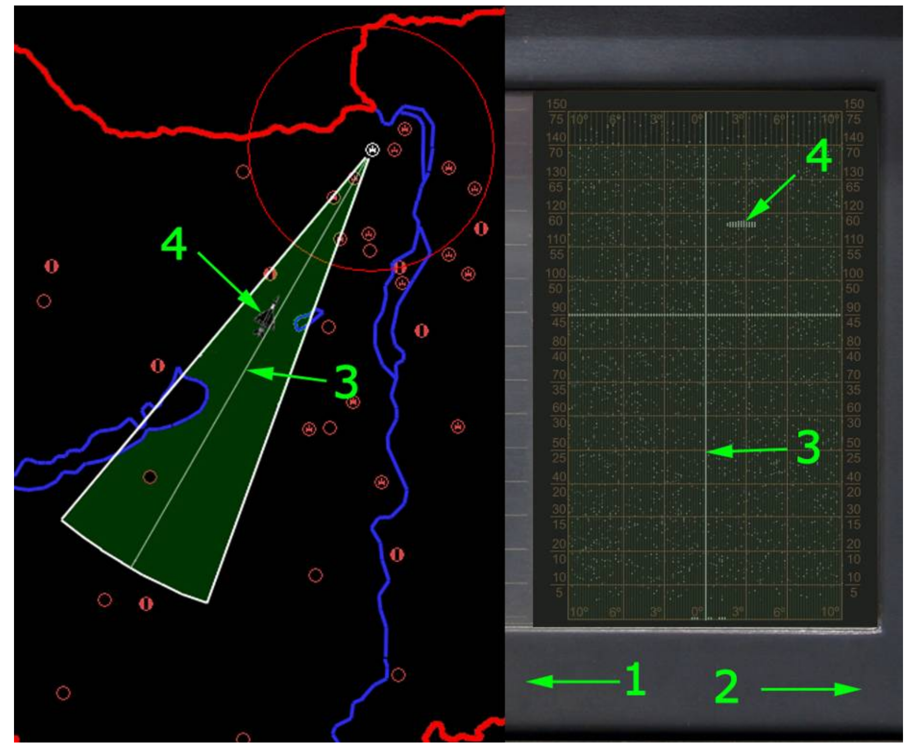
ε (Epsilon) – elevation – left side indicator – up/down direction



1. Direction down
2. Direction up
3. Boresight
4. Target under the boresight
5. Reflection from the ground

β (Beta) – azimuth – right side indicator – right/left direction

1. Direction left
2. Direction right
3. Boresight
4. Target at the right of the boresight



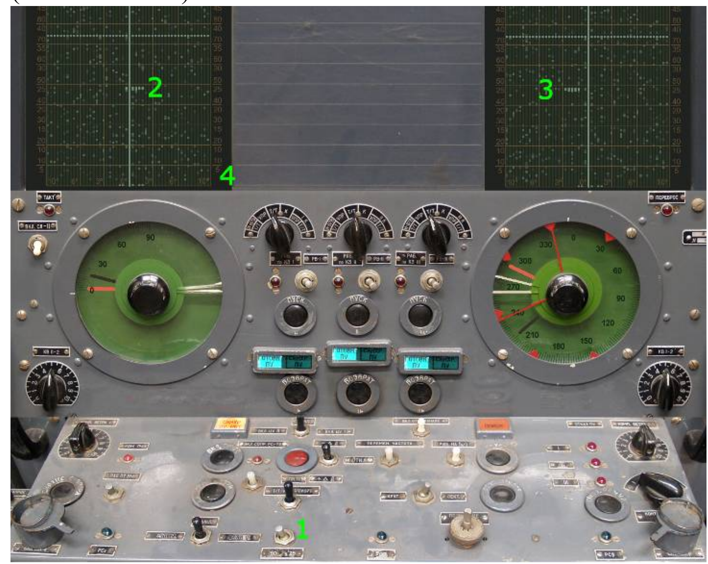
Range modes

Two main range modes can be selected, 75km and 150km. In 150km mode, only half of the electromagnetic impulses are sent, as they have to travel double range, compared to the 75km mode.

The two secondary range modes are only the magnification of the main range modes. The 5km mode can be selected in both of main modes (75/150km), and is a magnification of the ±2.5km area around the range boresight. The 35km mode shows the first 35km of the 150km mode's display.

150km

(Z or Y - button)



1. Range selector switch (**<u>left 150km</u>** – right 75km)
2-3. Target at 48km. The upper range scale should be used.
4. Range scale.
Both scales are always visible. (5-75 and 10-150)

75km

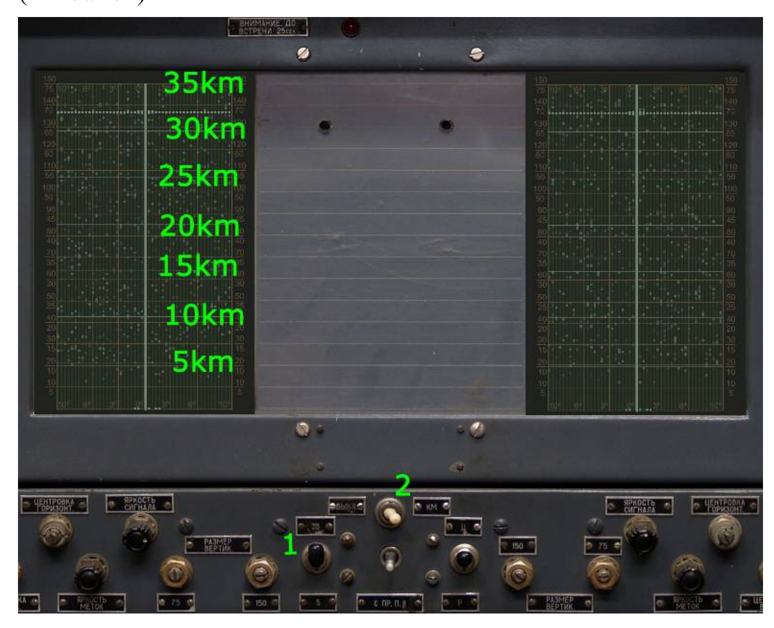
(Z or Y - button)



1, Range selector switch (left 150km – **<u>right 75km</u>**)
2-3, Target at 42km. The lower range scale should be used.

35km

(A - button)



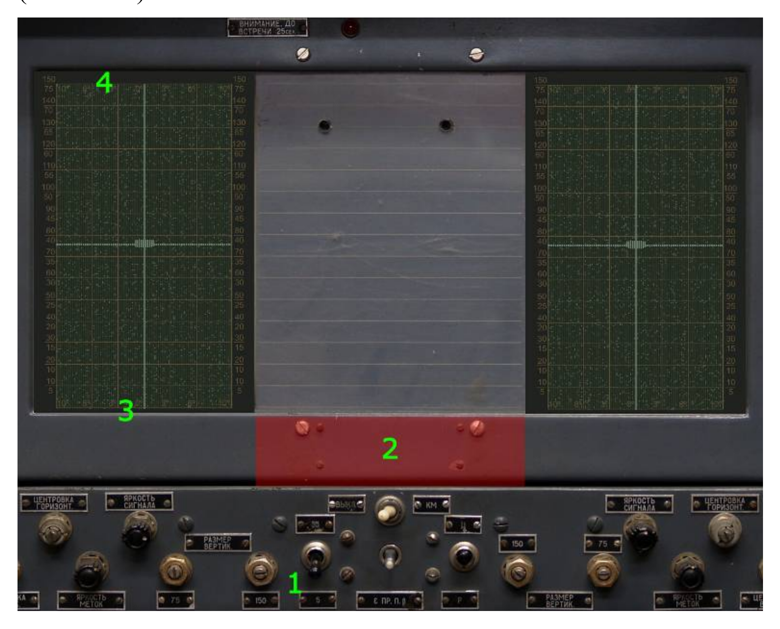
It is possible to magnify the first 35km of the 150km range mode.

1. 35km range switch (up).

Because the range scale is only for the main modes (75/150km), a 5km electronic scale could be turned on (2 - right). (target at 32km)

5km

(A - button)



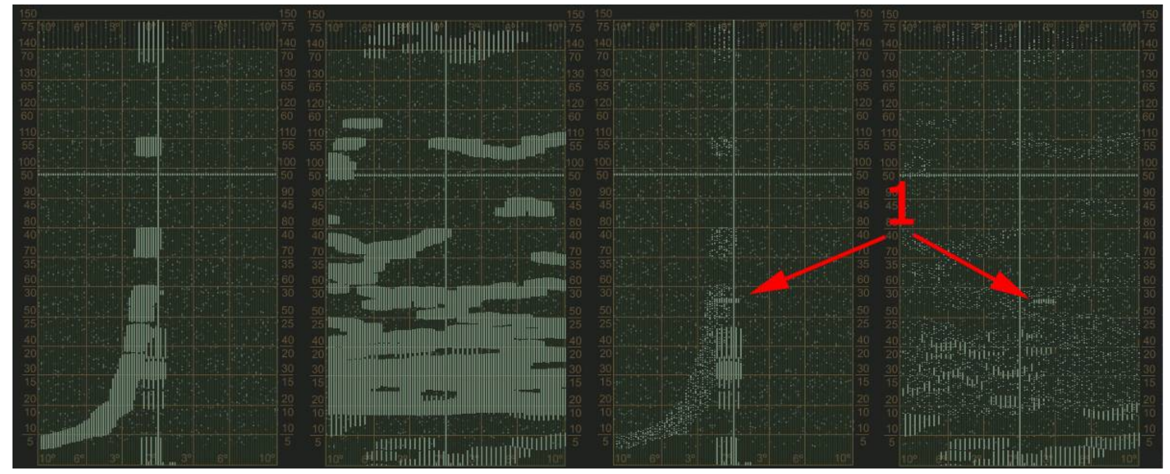
Using both main range modes (150/75km), the 5km area around the range boresight could be magnified. Note that the scales on the sides of the scope are now meaningless

1. 5km range switch (down).
3. target range minus 2,5km
4. target range plus 2,5km

Holding down the left mouse button in the red area (2), and moving it to right-left, we can move the range boresight (further-closer).

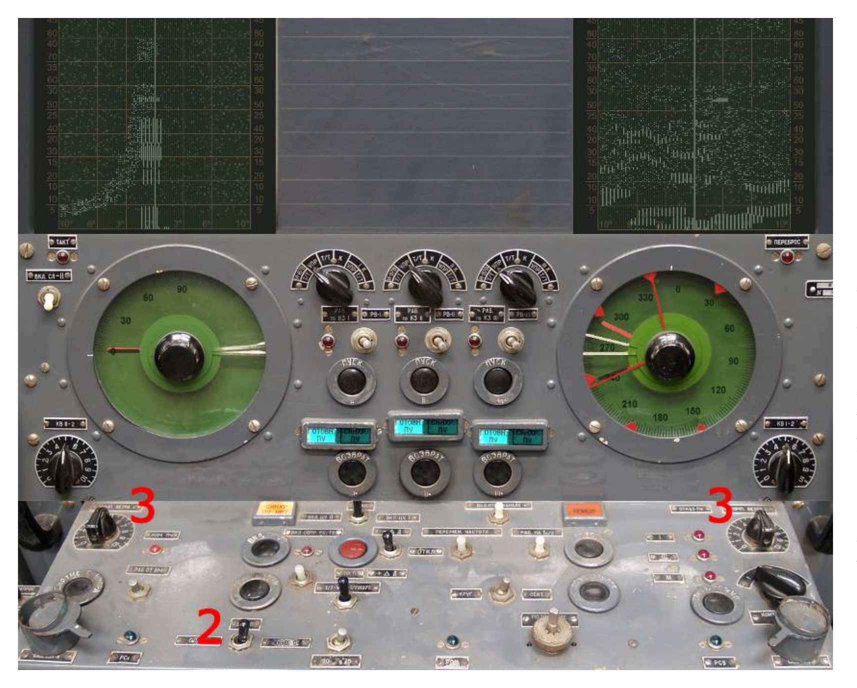
Using the SDC (Moving Target Indicator) to reduce ground clutter

If the target is flying at very low altitude, the ground clutter can make the target acquisition difficult. The SDC using the impulse Doppler mode of the SNR can differentiate between the targets by their radial speed. Important to note, that by the usage of SDC, low radial speed (hovering or parallel flying) targets can completely disappear from the indicator.



Indicators without SDC   Indicators with SDC

1. Low flying target in heavy ground clutter, not visible without SDC.

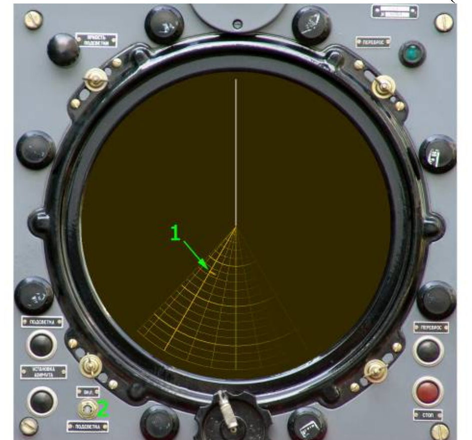


2. SDC mode selector switch settings:
SDC2, left - not used
OFF, middle
SDC1, right – SDC on

3. The SDC can be fine tuned by holding down the left mouse button over the compensation knob, and moving it to right-left. Each indicator has separate “wind compensation” knobs.

Target acquisition using P-18 Spoon Rest-D Radar

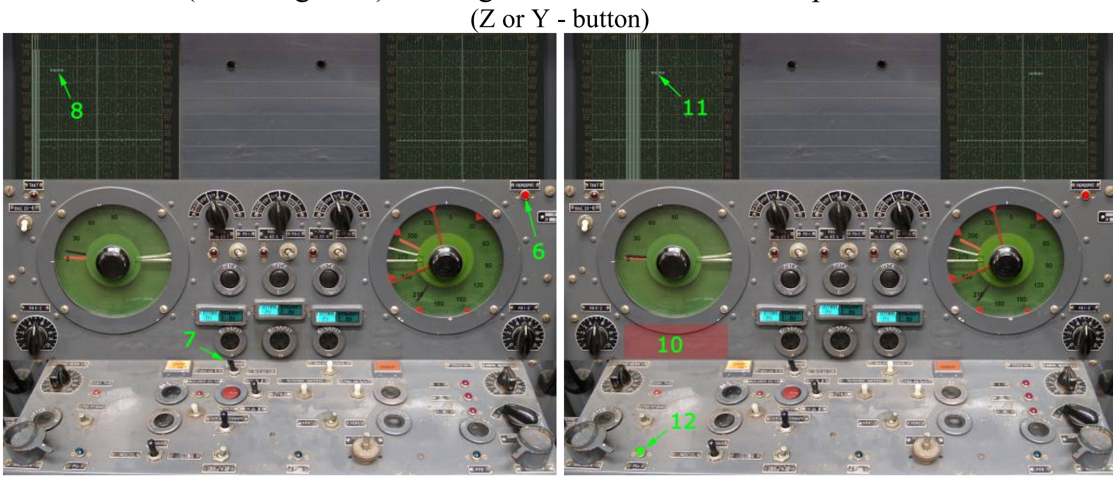
(X - button)





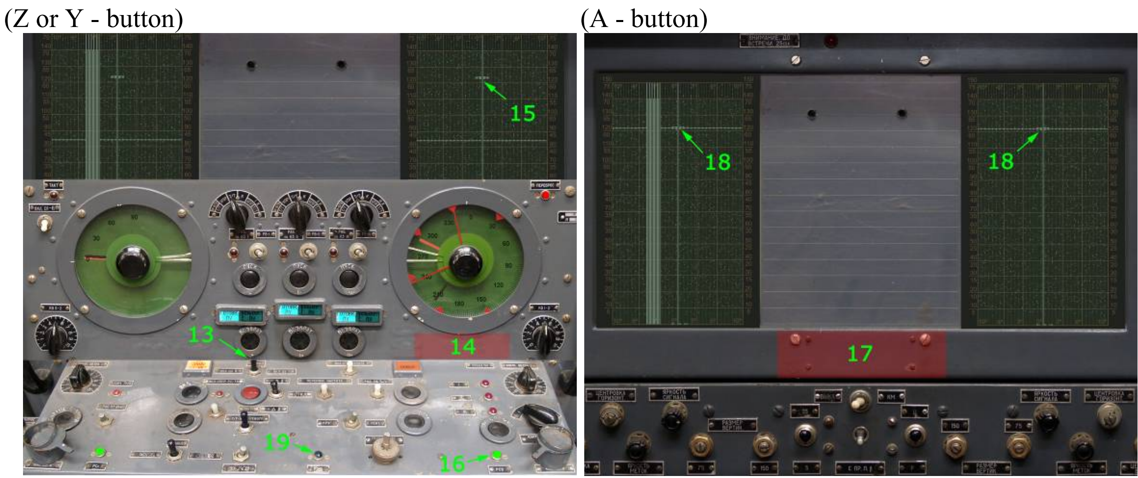
1. Target at 217˚, 68km range
2. Adjustment raster is turned off
3. Holding down the left mouse button in the red area, and moving it to right-left, we can move the white azimuth marker (right-left).
4. To slave the RSN-75, push ПЕРЕБРОС (throwing over) target acquisition in azimuth.
5. ПЕРЕБРОС (throwing over) sending the marked azimuth lamp illuminates.

(Z or Y - button)



6. ПЕРЕБРОС, (throwing over) receiving the marked azimuth lamp illuminates.
7. ВКЛ. ЦУ II, (receiving the 2nd type of target acquisition) switch - left.
In azimuth, the RSN-75V3 is continuously following the P-18 azimuth marker.
8. When the target shows up, we acquire it (see: rotating the RSN-75V3). If the boresight touches the target, we can click with the right mouse button in the red area (10), and the target gets into automatic tracking in elevation (11). The PCε (Target is in automatic tracking – in elevation) lamp is illuminated (12).

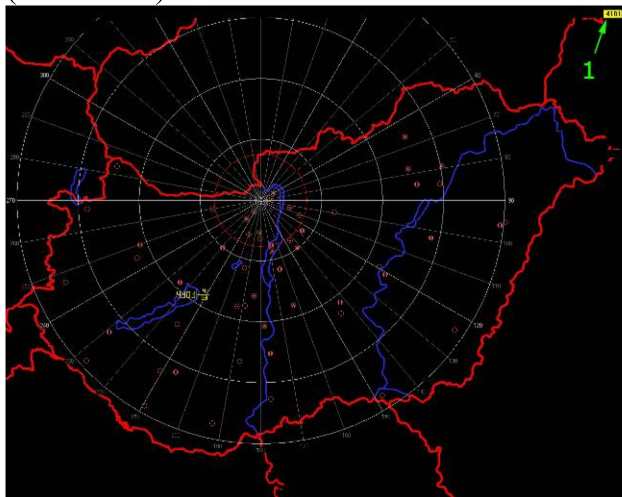
(Z or Y - button) (A - button)



13. ВЫКЛ, (receiving the target acquisition - off) switch – in the middle.
We acquire the target in azimuth (see: rotating the RSN-75V3). If the boresight touches the target, we can click with the right mouse button in the red area (14), and the target gets into automatic tracking in azimuth (15). The РСβ (Target is in automatic tracking – in azimuth) lamp is illuminated (16).
17. Holding down the left mouse button in the red area, and moving it to right-left, we can move the range boresight (further-closer). If the boresight touches the target, we can click with the right mouse button in the red area (17), and the target gets into automatic tracking in range (18). The РСД (Target is in automatic tracking – in range) lamp is illuminated (19).

Target acquisition with Vector-2VE/Senezh-ME, IADS

(W - button)

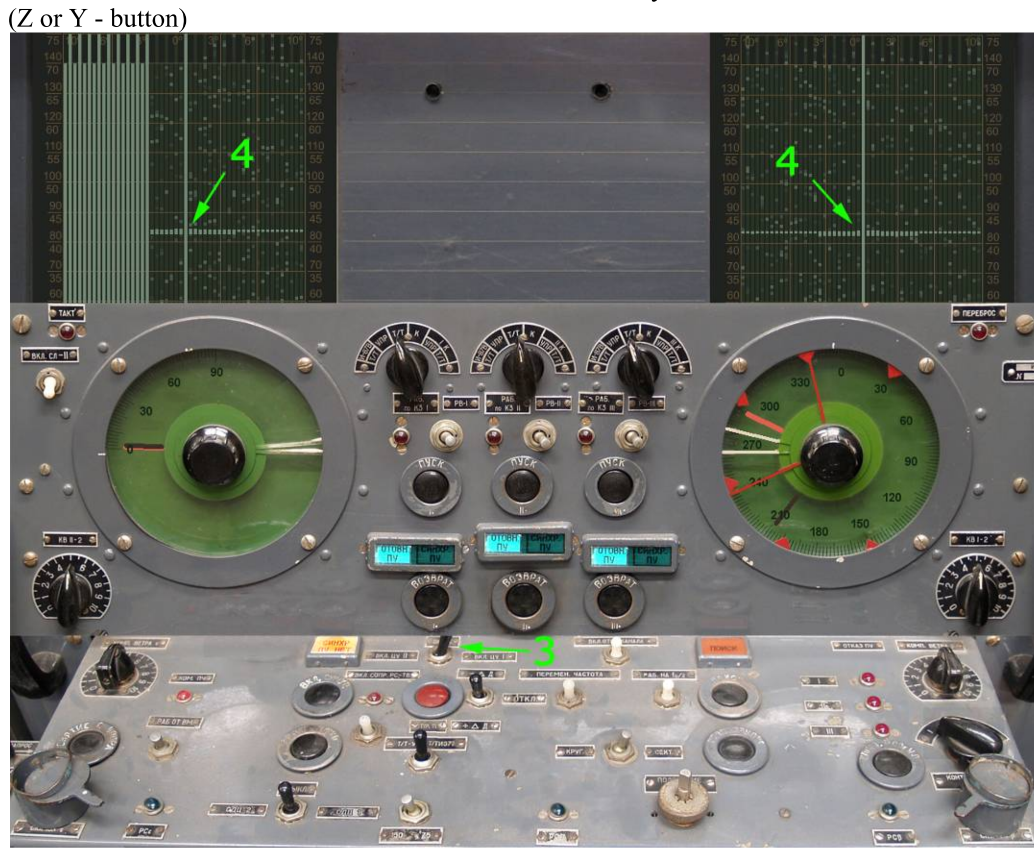


1. Clicking the target number in the plotting table, we can select automatic target acquisition.
(Q - button)



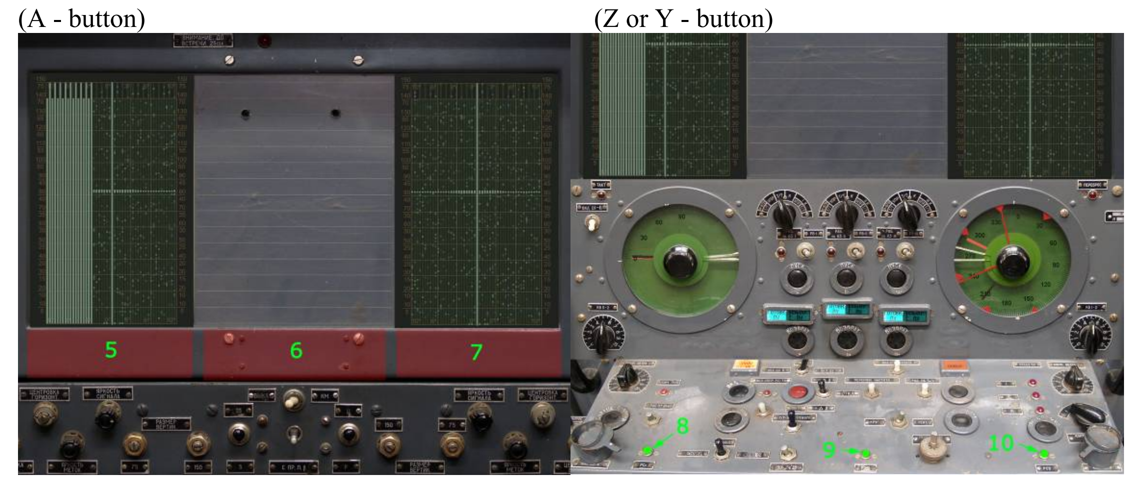
2. To increase target detection range, we use Narrow Beam, as the IADS provides accurate target location once every 10 seconds.

(Z or Y - button)



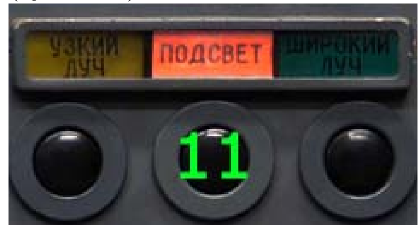
3. ВКЛ. ЦУ I, (receiving the 1st type of target acquisition) switch - right.
In azimuth, elevation, and in range, the RSN-75V3 is continuously following the IADS provided target acquisition, in every 10th second.
4. The wide target mark in Narrow Beam mode.

(A - button) (Z or Y - button)



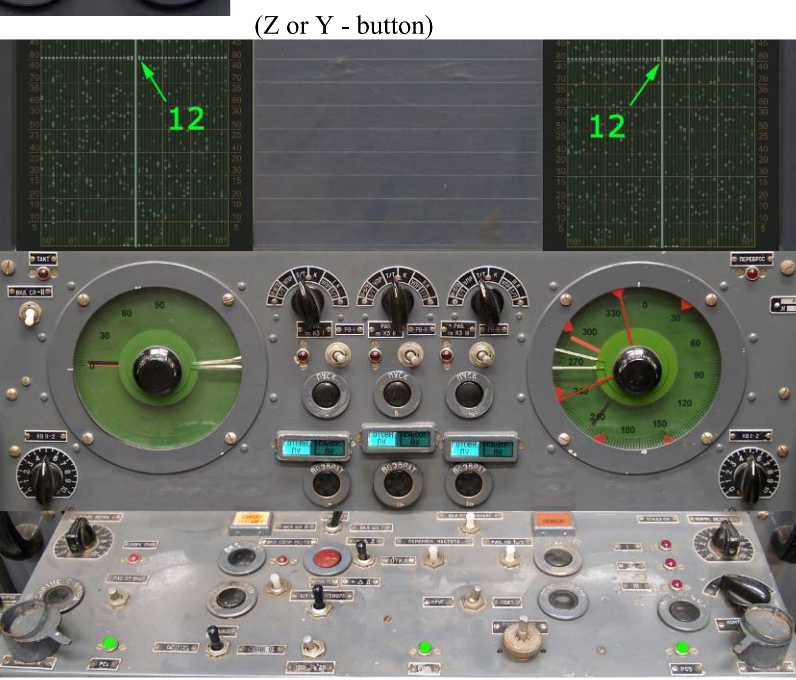
If the boresight touches the target, we can click with the right mouse button in the red area (5-6-7), and the target gets into automatic tracking in elevation – azimuth - range.
8. The PCε (Target is in automatic tracking – in elevation) lamp is illuminated.
9 The PCД (Target is in automatic tracking – in range) lamp is illuminated.
10. The PCβ (Target is in automatic tracking – in azimuth) lamp is illuminated.

(Q - button)



11. After a successful transition to automatic tracking, switch to the LORO mode, to be able to successfully guide missiles.

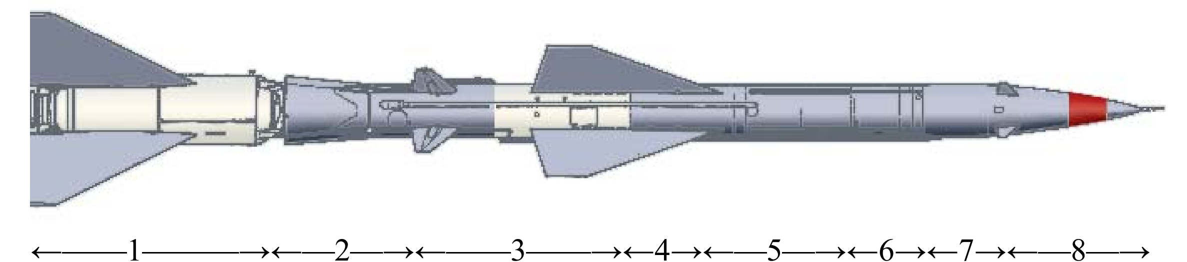
(Z or Y - button)



12. The narrow target mark in LORO mode.

V-755 20D (Guideline Mod.3) surface to air missile

Fielded from 1961, it was based on the S-75 Desna (SA-2C) system V-750VN 13D (Guideline Mod.2) missile. Launch weight: 2,395kg. Length: 10.775m.



←——1———→←—2—→←——3———→←4→←—5—→←6→←7→←—8—→

1. **I. I. Kartukov - PRD-18R solid fuel booster.**
   Propellant: 14pcs nitrocellulose tube (outer/inner Ø: 13,5/2,6cm, length: 1,8m)
   Weight of the igniter - black powder: 2kg
   Empty/launch weight – thrust: 300/900kg - 500kN
   Burn time: 3s
   Max speed: 550m/s (Mach1.8)
2. **A. M. Isayev - S2.720 ZRD liquid fuel sustainer.**
   Weight / thrust: 47.5kg / 20.75-35kN (throttable)
   Range: 43km
   Max speed and overload capability (depending on target altitude):
   - at 300m altitude, 785m/s (Mach2.6), 5.5~6g
   - at 10km altitude, 910m/s (Mach3), 5.5~6.5g
   - at 25km altitude, 1125m/s (Mach3.7), 2.7~3g
   - at 30km altitude, 1230m/s (Mach4), 2.1~2.4g
3. **AP-755 autopilot, steering fins.**
   Time to spin up gyroscopes before launch: 2 minutes
   Time to keep gyroscopes spinning without overheating: 25 minutes
4. **Air pressure bottle for the fuel and steering system. (270-350bar)**
5. **AK-20K "Melanj" oxidizer ("O" substance) tank.**
   Weight / Composition: 550kg / Nitric Tetroxide in solution with Nitric Acid, with Phosphoric and Fluoric acid inhibitors.
   20±2,5% N_2O_4, 73,4% HNO_3, 1-1,25% H_3PO_4, 0,5% HF, 2±0,8% H_2O
   Orange-brown, evaporating liquid. Self ignites combustibles. Highly corrosive, only few materials can withstand its effect: chromium steel, pure aluminum, glass, and for a short period, some rubber mixes.
6. **TG-02 "Samine" fuel ("G" substance) tank.**
   Weight / Composition: 250kg / mixture of xilidine, and triethylamine.
   50% $C_8H_{11}N$, 50% $C_6H_{15}N$
   Oily liquid, with color from yellow to dark-brown, and an odor typical for satured animes. Strong nerve agent, fatal concentration in air is: 18mg/liter!
7. **5B88 V-88M warhead.**
   Weight: 196kg
   Fragments: 8,200pcs
8. **5E11 radio proximity fuse, pitot tube**
   Minimum target altitude: 300m

V-755 20D Variants:

V-755 20DA

During the overhaul of 20D missiles, the 5E11 (USU) proximity fuse was incorporated, reducing the minimum target altitude to 100m. The new designation of these overhauled missiles is 20DA.

V-755 20DP

Missiles manufactured from 1962, incorporated the modified S2.720.A2 sustainer engine. This made it possible to engage subsonic targets after the engine ran out of fuel, using the un-powered or passive part of the trajectory. Range increased to 56km using this mode.

V-755 20DS

During the overhaul of 20DP missiles, the 5E11 (USU) proximity fuse was incorporated, reducing the minimum target altitude to 100m. The new designation of these overhauled missiles is 20DS.

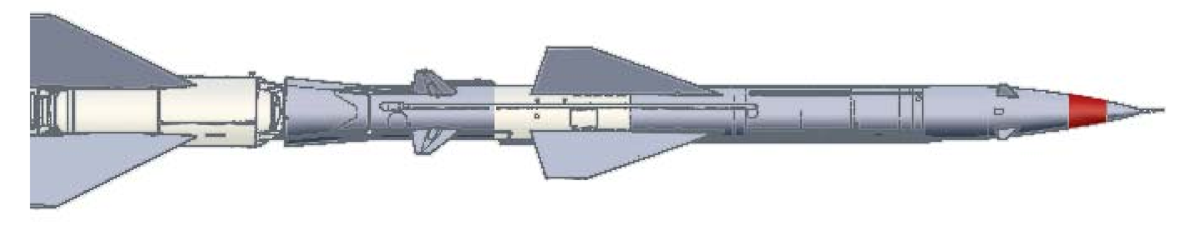
V-755U 20DU

Missiles manufactured from the second half of the sixties, the gyroscope spinup time was reduced from 2 minutes, to 30 second. Because of this modification, the time to keep gyroscopes spinning without overheating was decreased to 5 minutes from the original 25 minutes.



V-755U 20DSU (Guideline Mod.3) surface to air missile

During the overhaul of 20DU missiles, the 5E11 (USU) proximity fuse was incorporated. Hungary fielded the Volhov system with this type of missile in 1978.

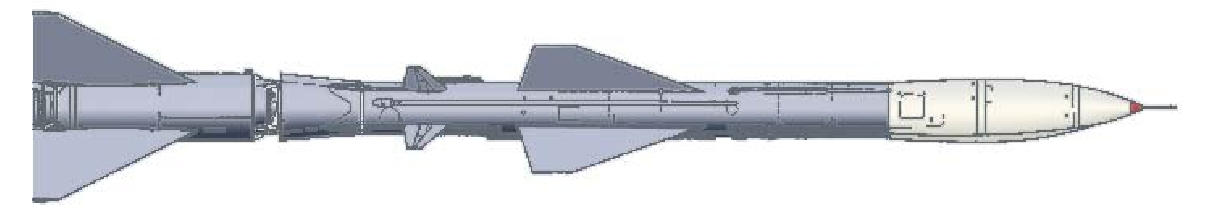


←——1———→←—2—→←——3——→←4→←—5—→←6→←7→←—8—→

1. **I. I. Kartukov - PRD-18R solid fuel booster.**
   Propellant: 14pcs nitrocellulose tube (outer/inner Ø: 13,5/2,6cm, length: 1,8m)
   Weight of the igniter - black powder: 2kg
   Empty/launch weight – thrust: 300/900kg - 500kN
   Burn time: 3s
   Max speed: 550m/s (Mach1.8)
2. **A. M. Isayev - S2.720.A2 ZRD liquid fuel sustainer.**
   Weight / thrust: 47.5kg / 20.75-35kN (throttable)
   Range against supersonic/subsonic targets: 43/56km
   Max speed and overload capability (depending on target altitude):
   - at 300m altitude, 785m/s (Mach2.6), 5.5~6g
   - at 10km altitude, 910m/s (Mach3), 5.5~6.5g
   - at 25km altitude, 1125m/s (Mach3.7), 2.7~3g
   - at 30km altitude, 1230m/s (Mach4), 2.1~2.4g
3. **AP-755 autopilot, steering fins.**
   Time to spin up gyroscopes before launch: 30 second
   Time to keep gyroscopes spinning without overheating: 5 minutes
4. **Air pressure bottle for the fuel and steering system. (270-350bar)**
5. **AK-20K "Melanj" oxidizer ("O" substance) tank.**
   Weight / Composition: 550kg / Nitric Tetroxide in solution with Nitric Acid, with Phosphoric and Fluoric acid inhibitors.
   20±2,5% N_2O_4, 73,4% HNO_3, 1-1,25% H_3PO_4, 0,5% HF, 2±0,8% H_2O
   Orange-brown, evaporating liquid. Self ignites combustibles. Highly corrosive, only few materials can withstand its effect: chromium steel, pure aluminum, glass, and for a short period, some rubber mixes.
6. **TG-02 "Samine" fuel ("G" substance) tank.**
   Weight / Composition: 250kg / mixture of xilidine, and triethylamine.
   50% $C_8H_{11}N$, 50% $C_6H_{15}N$
   Oily liquid, with color from yellow to dark-brown, and an odor typical for satured animes. Strong nerve agent, fatal concentration in air is: 18mg/liter!
7. **5B88 V-88M warhead.**
   Weight: 196kg
   Fragments: 8,200pcs
8. **5E11 (USU) radio proximity fuse, pitot tube**
   Minimum target altitude: 100m

V-760 15D (Guideline Mod.4) surface to air missile

Fielded from 1964, to engage attacking strategic bomber formations, the 15kt nuclear warhead tipped 15D missiles was employed.



The radio command receiver and the AS-1N robot pilot were doubled. The destabilization wings from the nose were deleted. The weight increased to 2,450kg, the length to 11.8m.
Each battery had an inventory of 3 missiles of this type, stored in the climate-controlled 7A building. PR-11D TZM missile transporter-loader vehicles, capable of climate-control the warhead during transportation, loaded these missiles to the launchers.

V-760V 5V29 surface to air missile

Fielded from 1975, this was a modernized version of the V-760, based on the V-759.

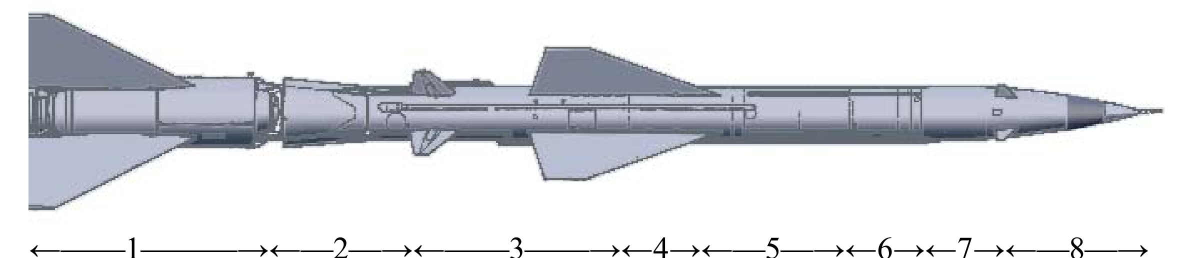




To be able to pinpoint the exact distance of the attacking formations, the RD-75 rangefinder 30cm wavelength radar was introduced.

V-759 5Ya23 (Guideline Mod.5) surface to air missile

Fielded from 1971, the V-759 has an improved warhead and increased maneuverability.
Launch weight: 2,406kg Length: 10.806m
Hungary fielded this type of missile from 1983.



←——1———→←—2—→←———3———→←4→←—5—→←6→←7→←—8—→

1. **I. I. Kartukov - PRD-18R solid fuel booster.**
   Propellant: 14pcs nitrocellulose tube (outer/inner Ø: 13,5/2,6cm, length: 1,8m)
   Weight of the igniter - black powder: 2kg
   Empty/launch weight – thrust - burn time: 300/900kg - 500kN – 3s
   Max speed: 550m/s (Mach1.8)
2. **A. M. Isayev - S2.720.A2 ZRD liquid fuel sustainer.**
   Weight / thrust: 47.5kg / 20.75-35kN (throttable)
   Range against supersonic/subsonic targets: 43/56km
   Max speed and overload capability (depending on target altitude):
   - at 300m altitude, 785m/s (Mach2.6), 6~7g
   - at 10km altitude, 910m/s (Mach3), 7~9g
   - at 25km altitude, 1125m/s (Mach3.7), 3~3.3g
   - at 30km altitude, 1230m/s (Mach4), 2.1~2.4g
3. **AP-755 autopilot, steering fins.**
   Time to spin up gyroscopes before launch: 30 second
   Time to keep gyroscopes spinning without overheating: 5 minutes
4. **Air pressure bottle for the fuel and steering system. (270-350bar)**
5. **AK-20K "Melanj" oxidizer ("O" substance) tank.**
   Weight / Composition: 550kg / Nitric Tetroxide in solution with Nitric Acid, with Phosphoric and Fluoric acid inhibitors.
   20±2,5% N_2O_4, 73,4% HNO_3, 1-1,25% H_3PO_4, 0,5% HF, 2±0,8% H_2O
   Orange-brown, evaporating liquid. Self ignites combustibles. Highly corrosive, only few materials can withstand its effect: chromium steel, pure aluminum, glass, and for a short period, some rubber mixes.
6. **TG-02 "Samine" fuel ("G" substance) tank.**
   Weight / Composition: 250kg / even mixture of xilidine, and triethylamine.
   50% $C_8H_{11}N$, 50% $C_6H_{15}N$
   Oily liquid, with color from yellow to dark-brown, and an odor typical for satured animes. Strong nerve agent, fatal concentration in air is: 18mg/liter!
7. **5Z98 warhead.**
   Weight (explosive): 201 (90) kg
   Fragments: 29,000pcs
8. **5E11 (USU) radio proximity fuse, pitot tube.**
   Minimum target altitude: 100m

SM-90 PU launcher

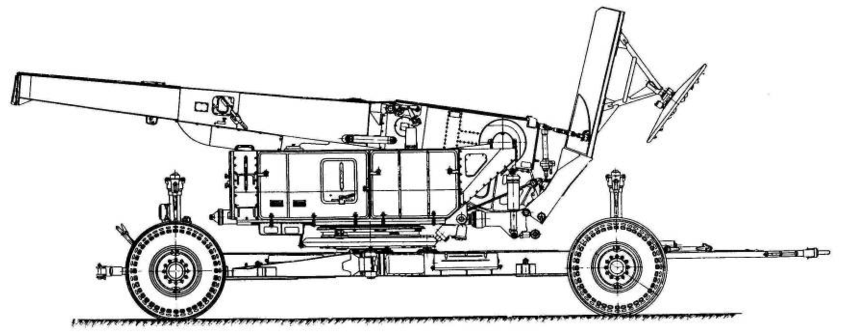
The battery has six launchers, with one missile per launcher.



V-755U 20DSU missile on SM-90 launcher



V-759 5Ya23 missile on SM-90 launcher



SM-90 PU launcher in towed configuration

PR-11B TZM missile transporter-loader

The TZM is a PR-11B missile transporter-loader semi-trailer, towed by a ZIL-131 truck. Missiles are reloaded from the TZM to the SM-90 launcher. Each battery has 3 fortified platoon entrenchments, holding a total of 6 TZM vehicles, each carrying one missile.



Fortified platoon entrenchment

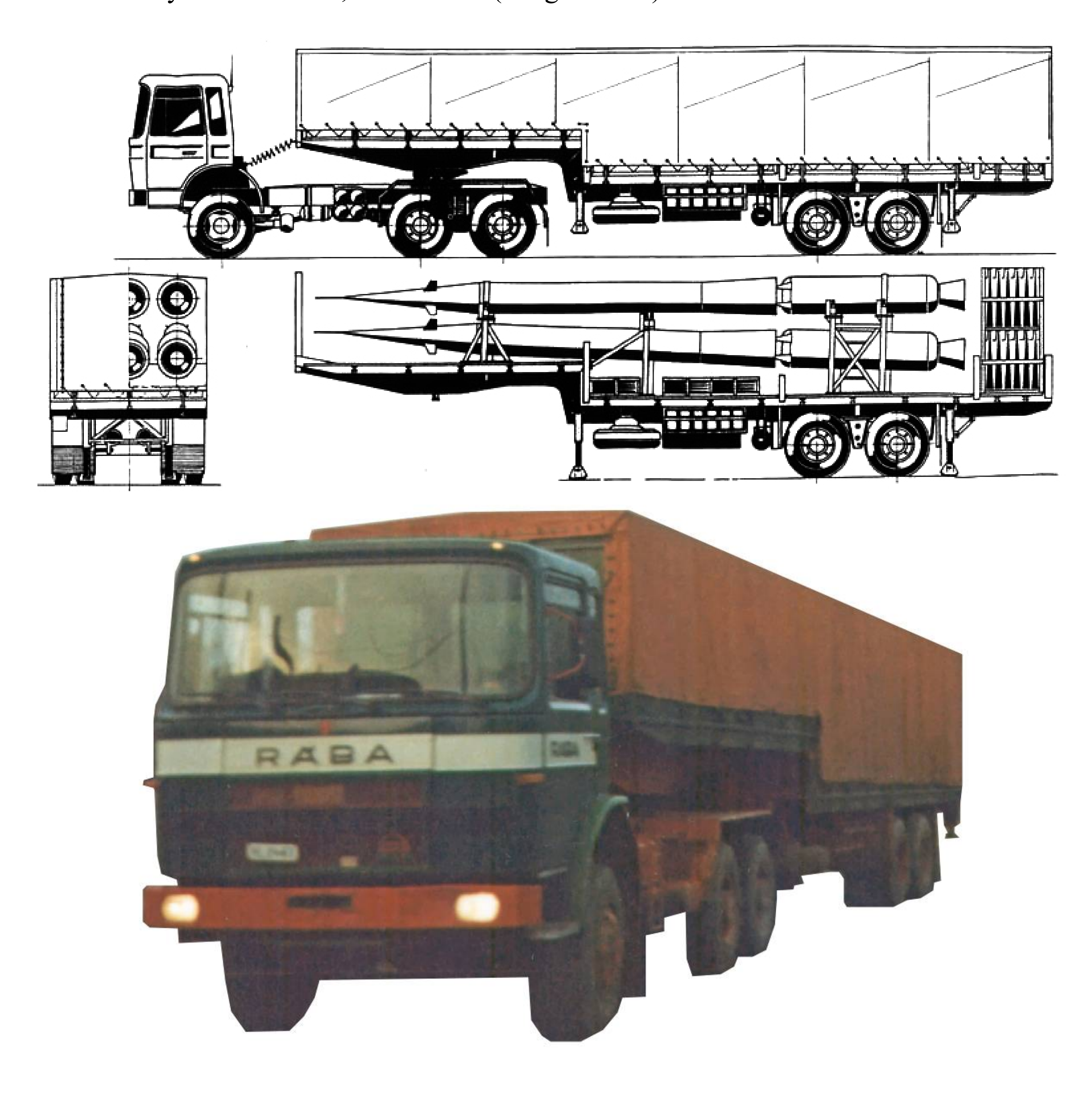
Each battery had 3 fortified platoon entrenchments. Each fortified platoon entrenchment was capable of protecting 2 TZM missile transporter-loaders.



Rába missile storage vehicle

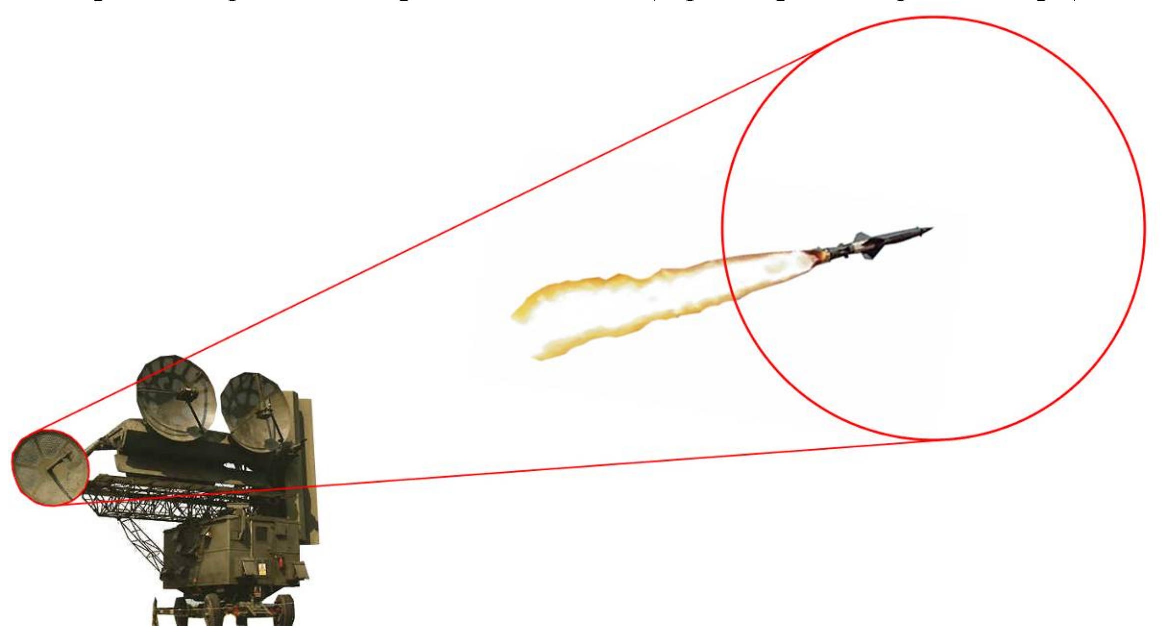
After the 1973 Middle East war, the Hungarian Army tripled the number of the available missiles of a battery, from 12 to 36. To store the 24 extra missiles, a transport vehicle was developed. The Military Institute developed the concept, and the Labor Precision Engineering Works Esztergom Factory created the missile storage vehicle in 1980. The trailer is suitable for transport and long-term storage of 6 missiles. The 5-axle vehicle is a 3-axle truck (Rába-MAN V.26.230.DFAS) and a 2-axle semi-trailer (082.46) capable of moving a full load of 6 missiles on subordinate, and dirt roads. A crane would move the missiles from the trailer to a cart so the fins – carried on the back of the trailer could be attached. The crane would then move the missile to a TZM for loading.

Each battery had 4 vehicle, to store 6-6 (altogether 24) extra missiles.



Selection of the missile guidance method

The missile doesn't "see" the target, it flies by remote control. The P-16 decimeter wavelength antenna is transmits the guidance signal commands (K1, K2, K3, and K4).
K1, K2 guidance signal (missile rudder angle command)
K3 radio proximity fuse arming command
K4 fragments dispersion configuration command (depending on the speed of target)



(Q - button)



The missile guidance method is selected depending on the target speed – altitude, and the existence of jamming.

After acquiring the target, its parameters can be read from:

- $\mathbf{P}_{KM}$ – The Course Parameter shows how far to either side of the site the target will pass. If the target flies directly towards us, the P=0km.
- $\mathbf{H}_{KM}$ – Target altitude in km.
- $\mathbf{V}_{Ц\ M/CEK}$ – Target speed in m/s.

Preparation for Missile launch

Preparation for simulated missile launch

To help crew training, an electronic missile simulator was built into the system.
It is possible to simulate missile launch and guidance with practice targets and get a hit rating. Since only one electronic missile simulator has been incorporated, only one electronic "missile" could be guided at a time.

(Q - button)



1. Pushing this button, the system switches to “practicing” mode and the KC lamp illuminates.
2. The electronic missile simulator is connected to one of the three missile channel (hI, hII, hIII). The simulated missile can be launched in the selected channel.

Preparation of the 5Ya23 V-759 (Guideline Mod.3) missiles

(Q - button)



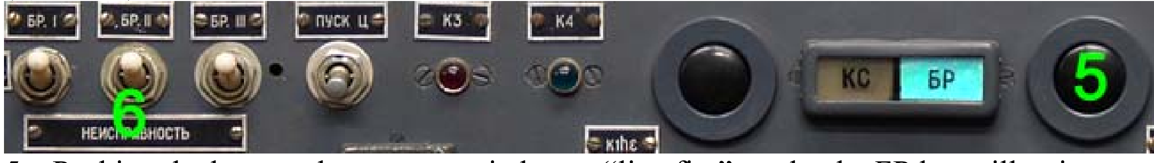
1. ТРЕВОГА: The alarm can be sounded with this switch :)
2. ГОТОВИТЬ: The number of missiles to be prepared for launch should be selected. 0-3-6-Н (Н - Prepare all available missiles)
3. ПОДГОТ. ПУ 1...6: The lights indicate that the missile is under preparation at the launcher (1..6). The V-759 missile's gyroscope requires ~30 seconds spinning up time.
4. ПУ-1...6: The lights indicate that the missile is ready to be launched. ПУ-1,2 belongs to missile channel-I, ПУ-3.4 to II, ПУ-5.6 to III.

(Z or Y - button)



When the missiles are ready, the ГОТОВН. ПУ lamps illuminate for the appropriate missile channels. The missiles could be kept in this ready to launch state for 5 minutes before the gyros overheated.

(Q – button)



5. Pushing the button, the system switches to "live fire" mode, the БР lamp illuminates.
6. БР I...III: All missile channels should be switched to "live fire" mode.



During peacetime, these switches are locked; no missile could be launched accidentally.

(Z or Y - button)



7. ВКЛ. СИНХР.: Pushing this button, the launchers are synchronized with the alignment of the RSN-75V3 fire control radar.
8. СИНХР ПУ НЕТ: Warning light extinguishes, synchronization is ongoing.
9. If the launcher is synchronized, the СИНХР. ПУ indicator is illuminated.

Selecting missile guidance method

Preparations for Shooting at High Altitude/High Speed Targets

(Q - button)



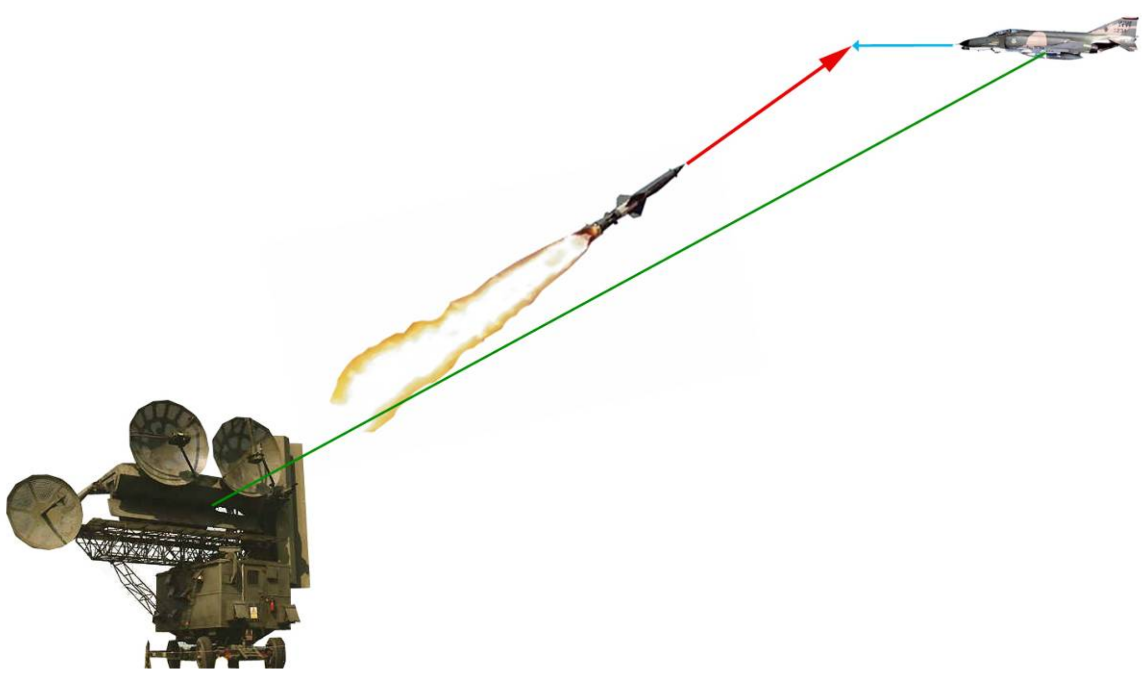
If the target parameters are in the green zone (H 5-35km, V 420-1000m/s), we set the missile radio proximity fuse to **ШТАН** (normal) sensitivity. Its sensitivity range is the maximum 300m in this case.

(Z or Y - button)



1-2-3. The missile guidance channels are switched to **УПР** "half-lead" guidance method. Using this guidance method, the missile is flying to pre-calculated impact point.

4. **ВКЛ. СЛ-II** switch-up. With this selected, if the missile misses the target it will continue on a ballistic path.



Preparations for Shooting at High Altitude/Low Speed Targets

(Q - button)



If the target parameters are in the green zone (H 5-35km, V<=420m/s), we set the missile radio proximity fuse to **ШТАН** (normal) sensitivity. Its sensitivity range is the maximum 300m in this case.

(Z or Y - button)



1-2-3. The missile guidance channels are switched to **T/T** “three-point” guidance method. Three-point guidance gets its name from the fact that the radar, missile and target are always lined up like three points on a straight line. In this mode the missile is always flying directly at the target.

4. **ВКЛ. СЛ-II** switch-up. With this selected, if the missile misses the target it will continue on a ballistic path.



Preparations for Shooting at Low Altitude Targets

(Q - button)

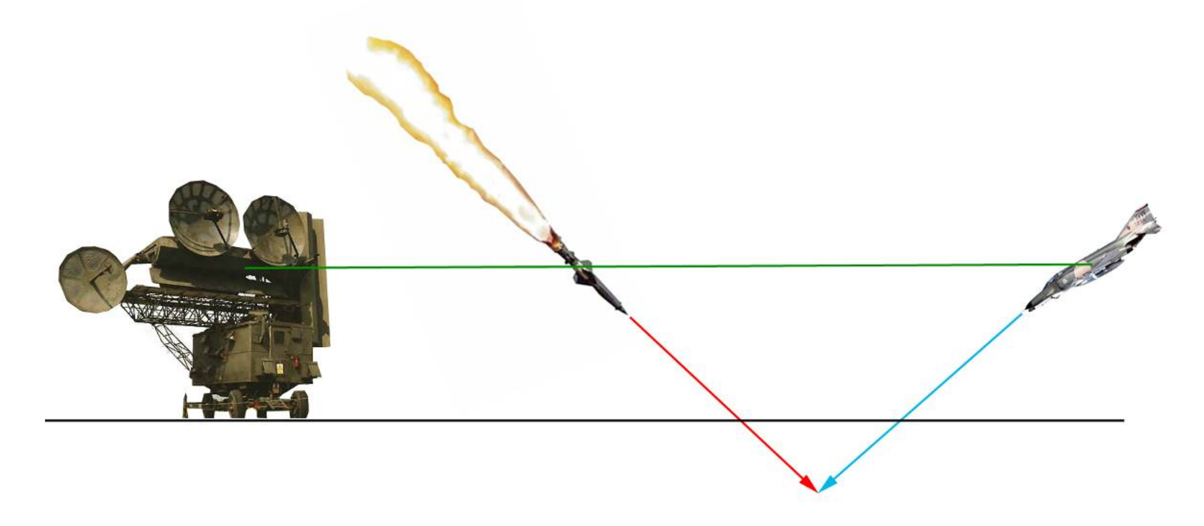


If the target parameters are in the green zone (H<5km, V<1000m/s), we use the (**K**) "half-lead, elevated by constant" guidance method (1-2-3), introduced after the Vietnamese war.



4. **ВКЛ. СЛ-I** switch-down. In this case, if the missile misses it will pitch up to fly a maximum climb profile.

During the Vietnam War, the American pilots discovered that a robust diving maneuver could cause the half-leading missile to crash into ground, as the calculated leading point is below the target. Using the "**K**" method the missile never aims below the target.



Depending on target altitude, there are three selectable radio proximity fusing methods...

Target altitude is below 5000m, but elevation is higher than 1,5°

(Q - button)



1. **H<5:** switch-up, H<5 lamp is illuminated.
2. If target elevation is higher than 1.5°, then the **ε<4.5º** lamp is not illuminated.
3. We set the missile radio proximity fuse to **ШТАН** (normal) sensitivity. Its sensitivity range is the maximum 300m in this case.

Target elevation is below 1.5°, but altitude is above 100m

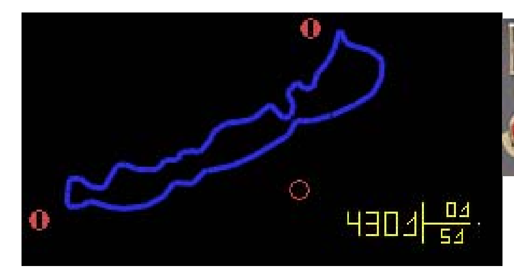
(Q - button)



1. **H<5:** switch-up, H<5 lamp is illuminated.
2. If the target elevation is below 1.5°, the **ε<4.5º** lamp is illuminated.
3. As the target altitude is between 180-650m, the normal radio proximity fuse setting (300m sensitivity) cannot be used. The fuse is set to **УСУ НЛЦ** ("USU"-gated) mode, reducing its sensitivity to 100m.

Target altitude is below 100m

(W - button) (Z or Y - button)



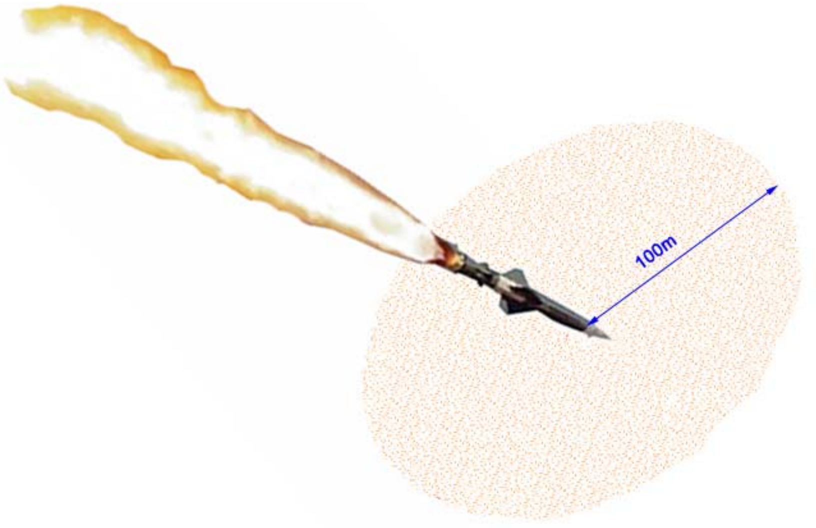


If the target altitude is below 100m, this will be shown on the plotting board notation by the altitude number **01**. In this case, the radio proximity fuse cannot be used, as the echoes from the ground would confuse it.

We switch off the radio proximity fuse (**РВ I-II-III**) on the three missile channel, and switch (**РАБ. по КЗ I-II-III**) explosion receiving **К3** command. During this mode, the explosion of the missile is commanded by the RSN-75V3 fire control radar, by transmitting the K3 command.

Preparations for Shooting at Ground Targets

The S-75M3 (SA-2E) system is capable of shooting on ground targets, closer than 25km (13.5 nm). The V-759 5Ya23 (Guideline Mod.5) missile's fragments cover an area 200 m (660 feet) wide. The destruction power of the supersonic (~4gram weight) fragments are comparable to an M-16 rifle bullet.



(Q - button)



1. After releasing the safety latch, push switch (1) left to enter the ЗЕМЛЯ (Ground) mode.

(Z or Y - button)



1-2-3. Select K, for the "half-lead, elevated by constant" guidance method.
4. **ВКЛ. СЛ-I** switch-down. In case of missing the target, the missile will fly with maximum climb path.

Determining the missile's launch envelope

The launch envelope is depending on the target parameters (speed, altitude, course parameter), and the missile interception method (half-lead, three-point).
Using these data, the APP-75V instrument is continuously calculating, and displaying the launch zone range marks.

(A - button)



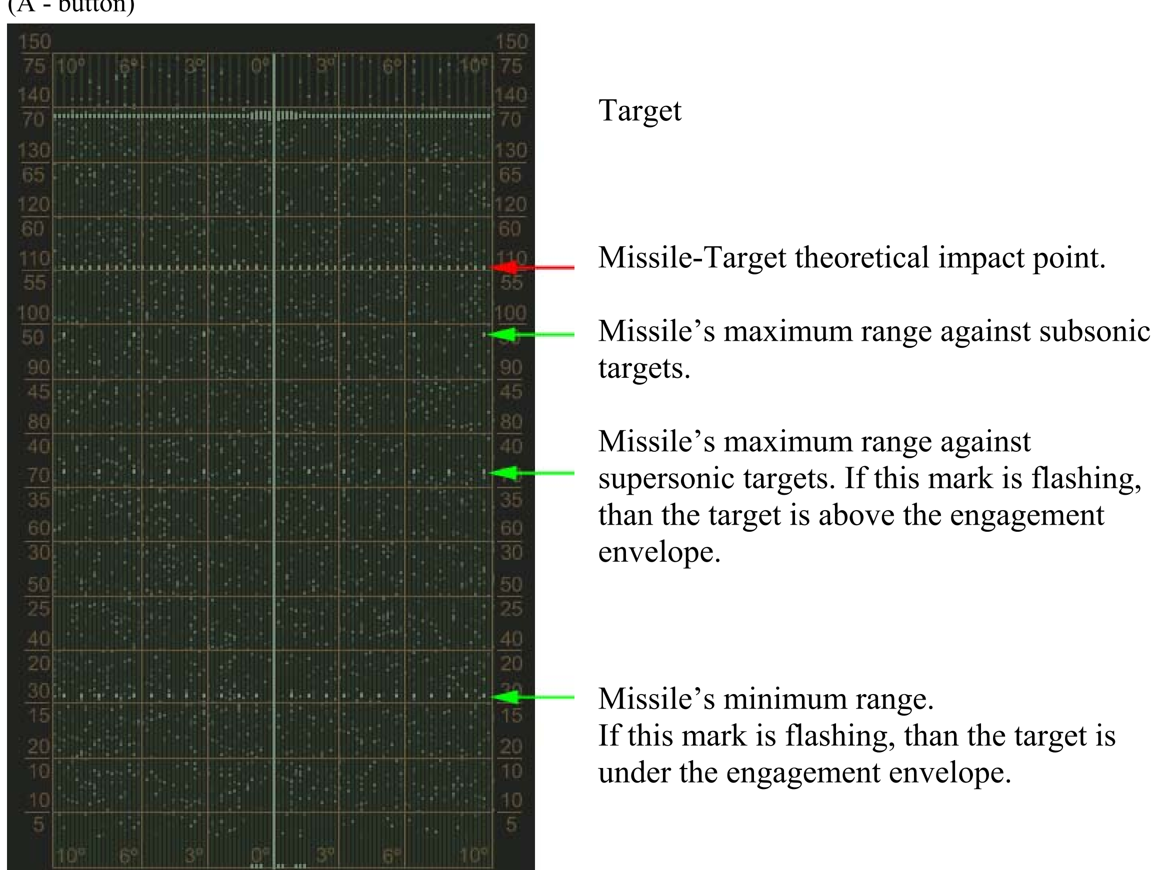
ε пр.п.β APP-75V instrument switch.
- Left: displaying the APP-75V range marks on the Epsilon indicator
- Middle: APP-75V instrument is switched off
- Right: displaying the APP-75V range marks on the Beta indicator

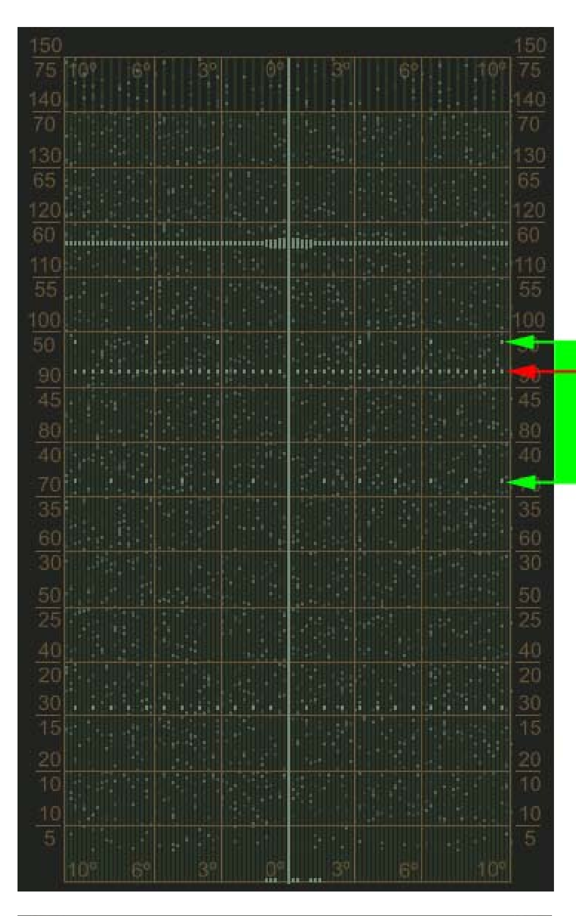
(Z or Y - button)



Т/Т-УПР-Т/ТИ87В Missile guidance method input switch for the APP.
- Left: APP is calculating by "Three-point" (**Т/Т**) guidance method.
- Middle: APP is calculating by "Half-lead" (**УПР**), or "half-lead, elevated by constant" (**К**) guidance method.

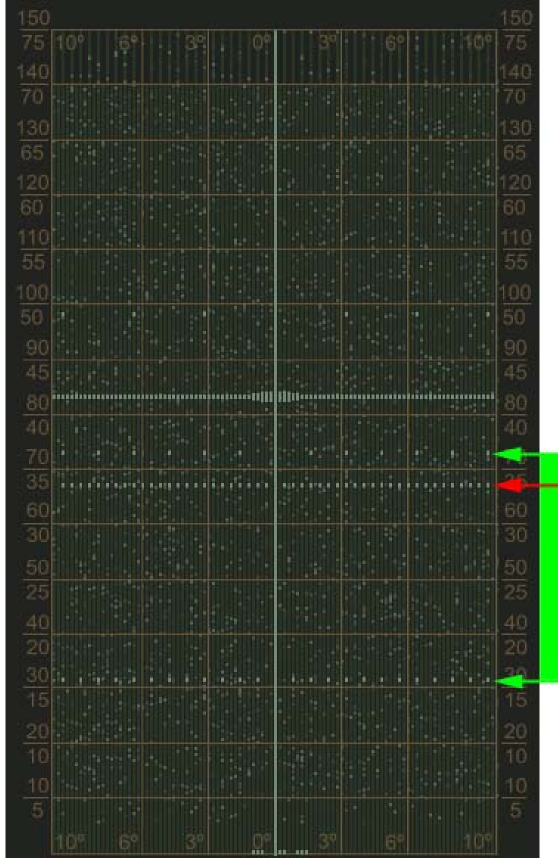
(A - button)





Target

Subsonic target (V<300m/s) is inside the launch envelope. Guidance method should be “Half-lead”.



Target

Target (V<1000m/s) is inside the launch envelope.

Ну Давай! ПУСК!

(Z or Y - button)



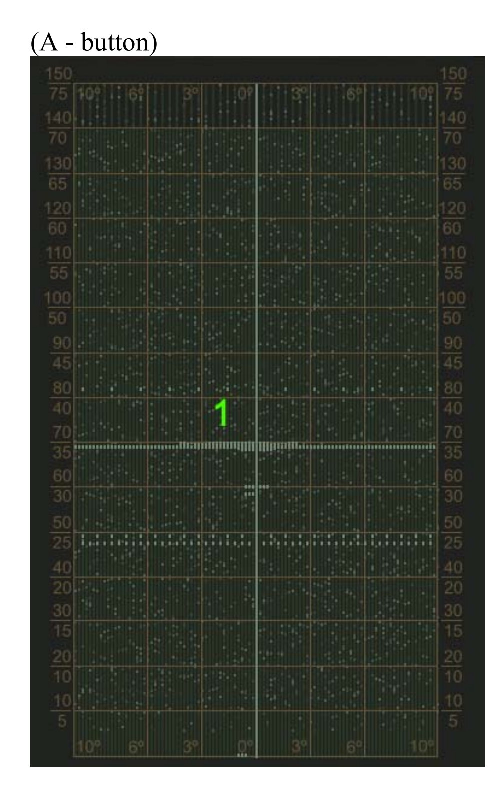
1-2-3. If the target is inside the launch envelope, the missile(s) can be launched with the **ПУСК I-II-III** button(s), keeping 6sec interval between the launches.
4. Keeping the 6sec separation between missile launches, the **ТАКТ** lamp is illuminated, blocking any premature launch.
5-6-7. Self destruction command to the missile(s) could be sent by the **ВОЗВРАТ I-II-III** button(s).

After pushing the **ПУСК** button, the launch command goes through the relays of the cabin, through the launcher, over the still attached OS-10 umbilical into the missile. First, the pyrotechnical switch opens the pressurized air valve. Pressurized air is required for the launch sequence, and during the flight, for operating the steering fins. It pops out the rubber plug from the end of the Pitot tube, and extends it. It pushes up the electrolyte from the plastic bags into the battery cell. After a fraction of a second, the battery is capable of providing full power. When the onboard power supply was ready, the solid fuel booster is ignited.
This sequence is completed within ~2sec from pushing the **ПУСК** button.

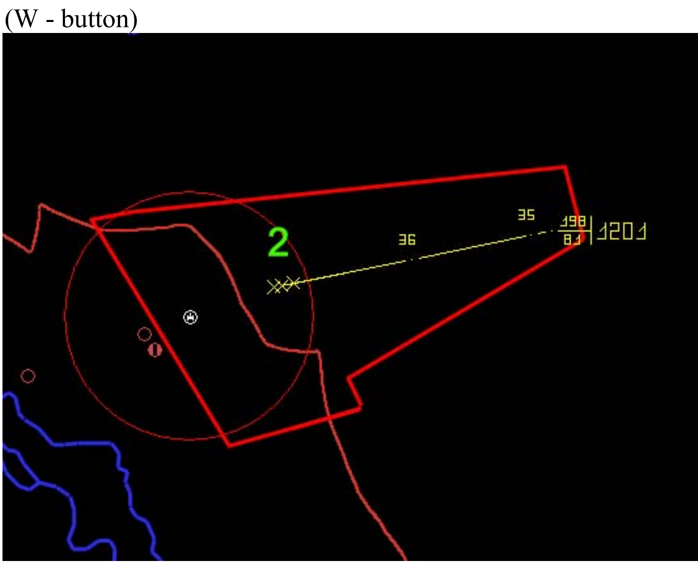
Observing the result of the shooting

Several factors are needed to be observed, to assess the result of shooting:

(A - button)

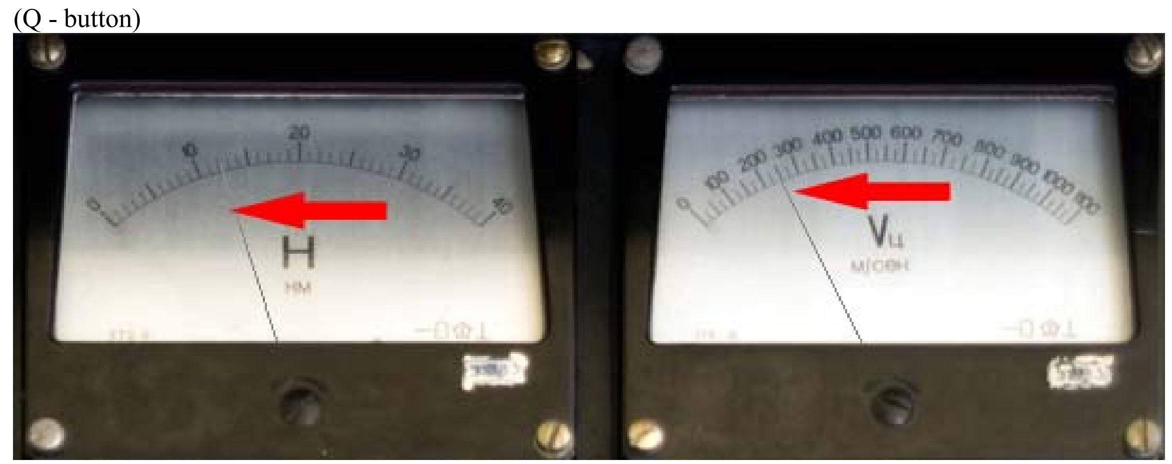


(W - button)



1. Target return “blossoms” when missile explodes.
2. The place of explosion is marked at the plotting chart by “X”. After successfully shooting at single target, the flight path of the target ends.

(Q - button)



Target destruction also shown by rapid decrease in target height and speed.

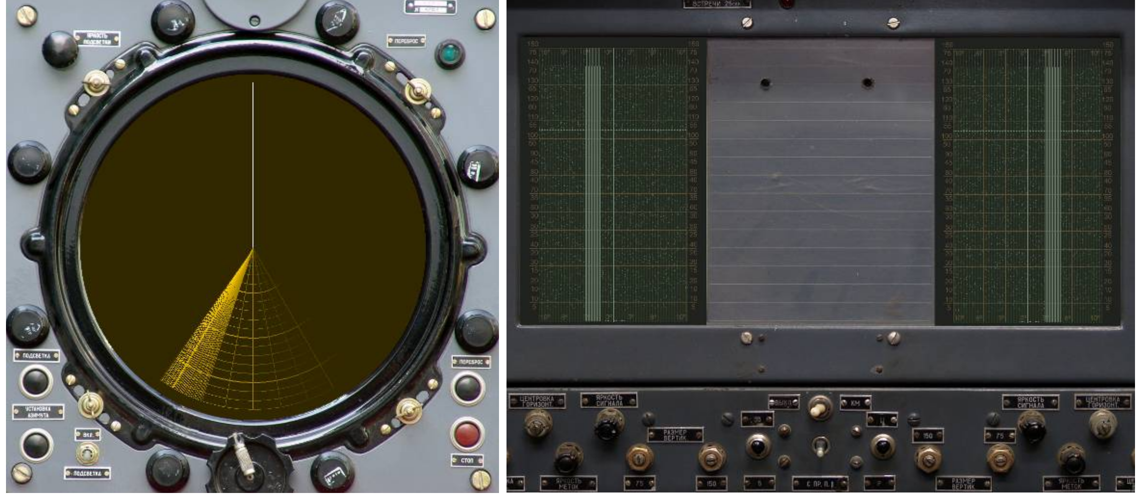
Electronic warfare

Noise jamming



Noise jamming pods, used since the middle of 60’s, are suppressing the radar echo of the carrier aircraft with strong noise, denying the range information from the fire control radar.

Metric wavelength noise jamming, centimeter wavelength noise jamming

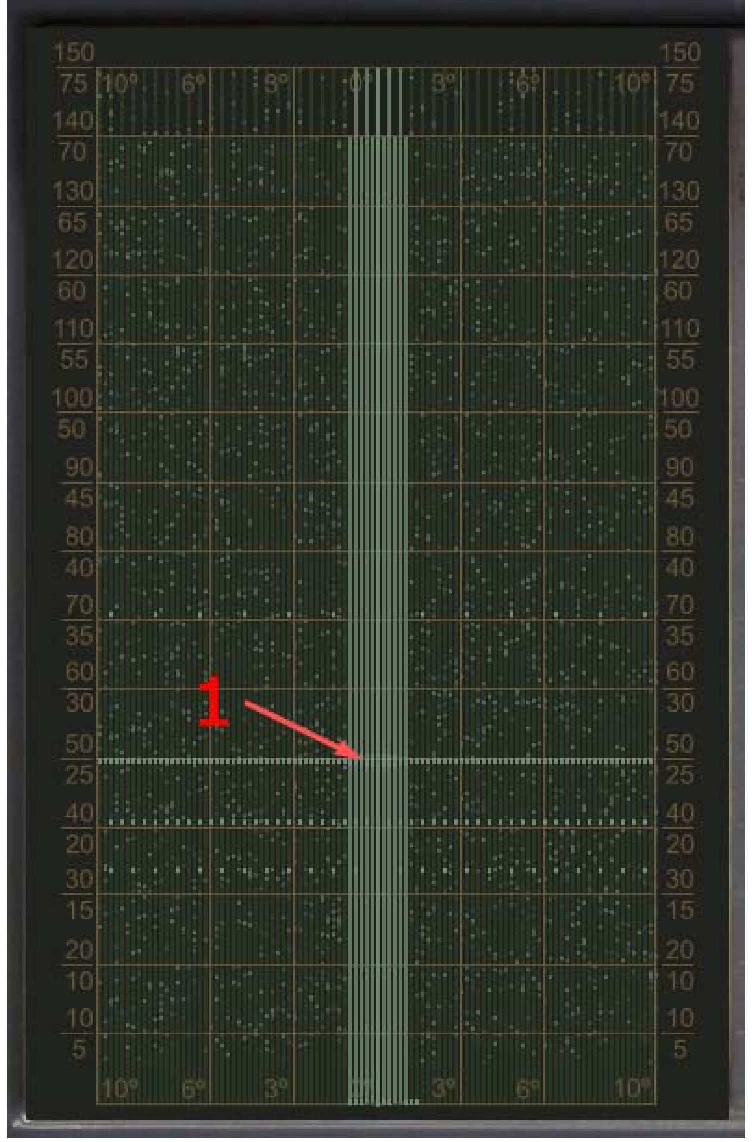


The noise jamming target is creating a vertical band in the indicators. It could be acquired in elevation and azimuth, but not in range.

Target is inside of the radar burn through range

If the target is inside the burn through range, the 1MW microwave impulses emitted by the SNR-75V3, and reflected from the target would be stronger than the noise jamming. In this case, the target (1) could be seen through the jamming and could be range tracked.

Shooting in this case is similar to a non-jamming target.



The burn through range is depending on the target aspect (heading in relation to the radar) and the radar beam type:

Against fighter-sized targets:

using wide-beam mode: 5 ~ 10km

using narrow beam - LORO mode: 10 ~ 20km

Against bomber-sized targets:

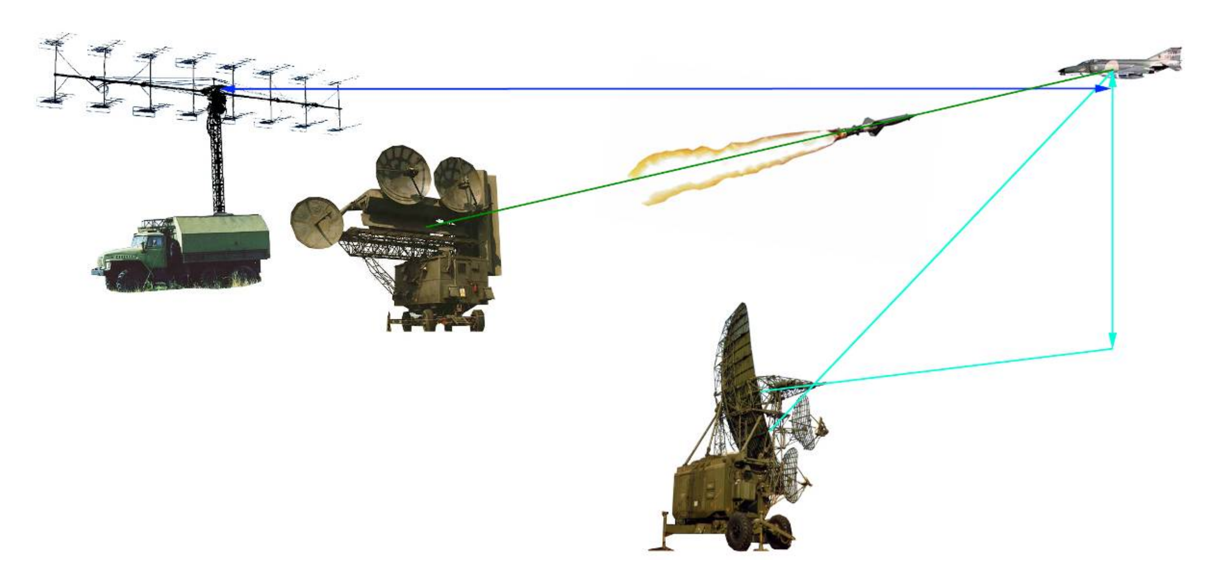
using wide-beam mode: 10 ~ 20km

using narrow beam - LORO mode: 15 ~ 30km

Preparations for Shooting at Noise Jamming Targets

Missile guidance with (И-87В/ТТ) “I87V-three-point”method

Against noise jamming targets, the I87V instrument is used. The missile is aimed towards the jamming target all the time. Target range is calculated by the I87V instrument, using the measured elevation, and manually input altitude data received from other sources and displayed on the plotting chart, (W- button), or distance from the P-18 radar, (X- button).



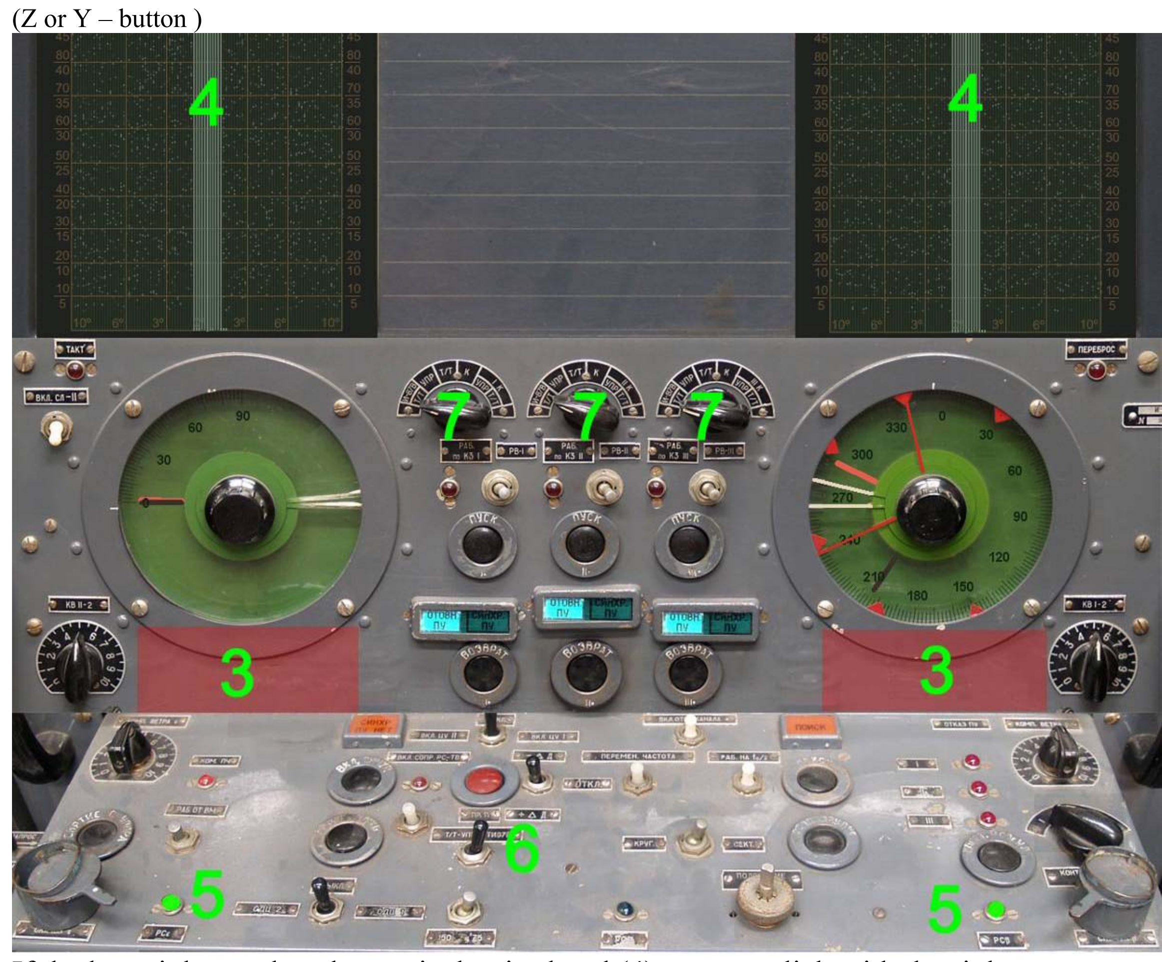
Shooting on noise jamming target

(Q - button)



Tracking of noise jamming targets could be done in passive mode, where the antenna receiver is open (1), but the transmitter is turned off (2). because the radar is not emitting it cannot be detected by electronic countermeasures and SIGINT receivers.

(Z or Y – button)



If the boresight touches the vertical noise band (4), we can click with the right mouse button in the red area (3), and the target goes into automatic tracking in elevation and azimuth. The PCε, PCβ (target is in automatic tracking in elevation, azimuth) lamps are illuminated (5).

6. **Т/Т | УПР | Т/ТИ87В**: Missile guidance method input switch for the APP.

- Right: APP is connected to the I87V instrument. Calculated target range is displayed.

7. The missile guidance channels are switched to **И87В Т/Т** "I87V-three-point" guidance method.

(W - button)

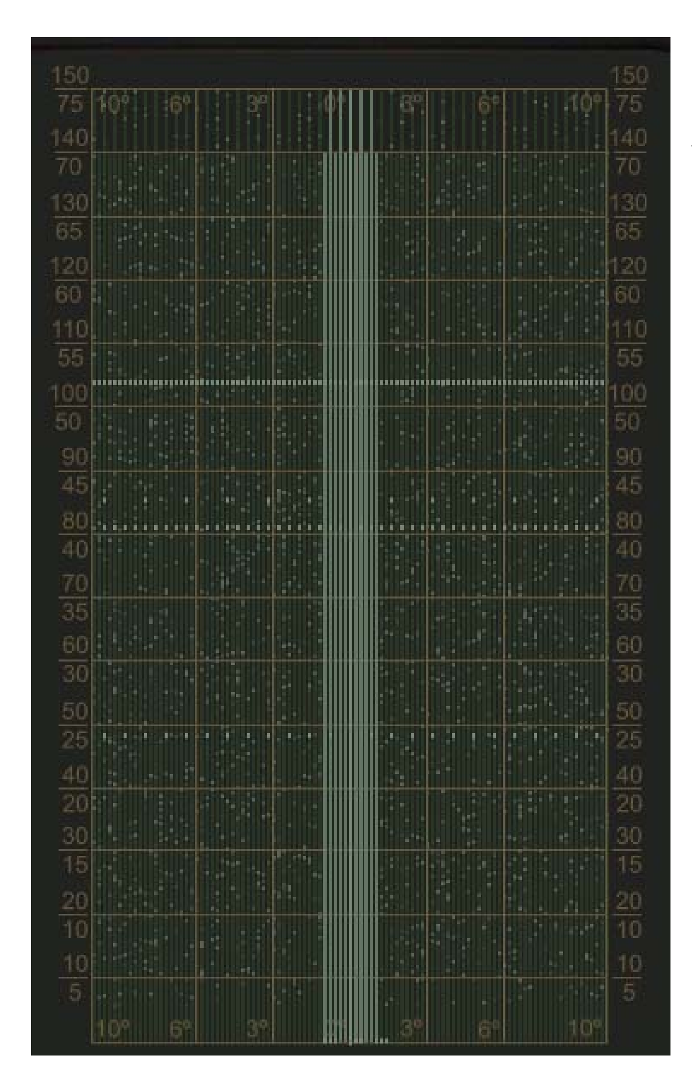


Jamming target altitude could be read off from the plotting chart. H=19,000m

(Q - button)



8. Holding down the left mouse button in the red area, and moving it to left- right, we can manually set the target altitude (9 – upper scale), or distance (10 – lower scale) into the I87V instrument.



Now the calculated distance of the jamming target is shown, it could be engaged as if it would be a normal target.

Anti Radiation Missile (ARM)

ARM’s, deployed since the 1960s, guide themselves to the microwave energy emitted by radars. As these missiles are visible in the radar screens, like fast approaching targets, the best defense against them is to turn the radar off in time.

Texas Instruments AGM-45 Shrike

The first fielded ARM, had significant limitations.



Fielded: 1963
Speed: 1,5Mach
Maximum Range: 45km
Length: 3,14m
Diameter: 20,3cm
Weight: 176kg
Warhead weight: 53kg

General Dynamics AGM-78 Standard ARM

The second ARM the US fielded, developed from the RIM-66 ship borne SAM. Provided increased speed, range and tactical flexibility.



Fielded: 1968
Speed: 1,8Mach
Maximum Range: 120km
Length: 4,2m
Diameter: 38cm
Weight: 589kg
Warhead weight: 100kg

Raytheon AGM-88 HARM

The state of the art ARM, it replaced the former types.

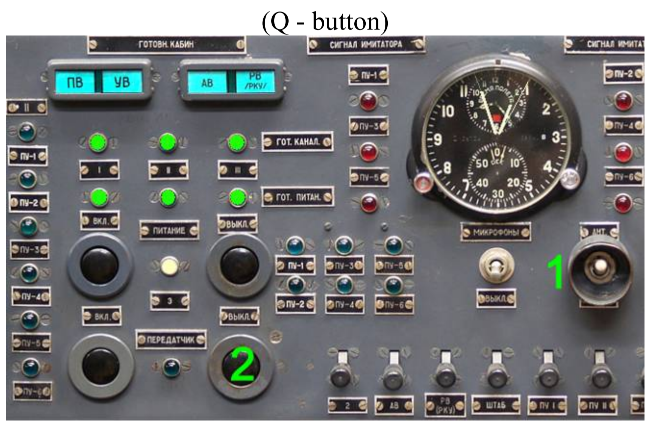


Fielded: 1982
Speed: 2,1Mach
Maximum Range: 150km
Length: 4,2m
Diameter: 25cm
Weight: 363kg
Warhead weight: 65kg

Target Engagement with Emissions Control

As our missile is always faster compared to incoming ARM’s, limiting radar emissions to the time period of missile guidance will dramatically increase the combat survivability of the system.

(Q - button)



Tracking of targets visually could be done in passive mode, where the antenna receiver is open (1), but the transmitter is turned off (2). Because the radar is not emitting it cannot be detected by electronic countermeasures and SIGINT receivers.





The black and white, daylight only, 67kg 9Ш38А ТОВ (9Sh38A TOV) optical target tracking camera has a wide 5° (F=150mm) and a narrow objective 1.5° (F=500mm). It was introduced during the planned 5 year maintenance (overhaul) as the S-75M3-OP Volhov (SA-2E) from 1983.

The small black and white TV screens in reality are located on the manual angle trackers instrument panel, but for playability reasons, in the simulator, it is shown on the Fire Control Officers panel.

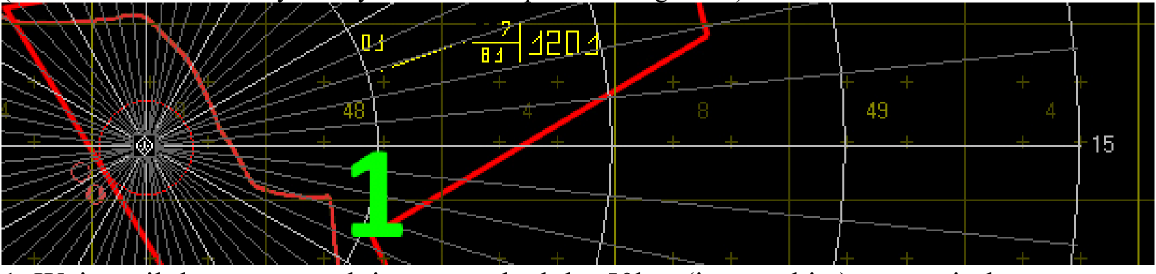
<-----Elevation-----> <-------Range-------> <-----Azimuth----->

(Z or Y - button)



1. Push the “**S**” button to show the TV screen.
2. **РАБ.РЕЖ. ВКЛ/ВЫКЛ**, switch the camera on/off
3. **УГОЛ ЗРЕНИЯ ШИРОКИЙ/УЗКИЙ**, wide/narrow objective selector
4. **T/T**, Select three point missile guidance method on all missile channels.
5. **РАБ ОТ ВМ**, Select radio proximity fuse arming right after launch, as we have information on the target exact range.
6. **ВКЛ. СОПР. РС-ТВ,** Select optical target tracking. This mode is blocking H<5 selection, and a red lamp illuminates above the switch.
7. **150/75**, keep the range selector switch at left (150km) mode, to avoid deceptive simulated missile launch.

(Press the “W” button on your keyboard to call up the Plotting board)



1. Wait until the target track is approached the 50km (inner white) range circle.

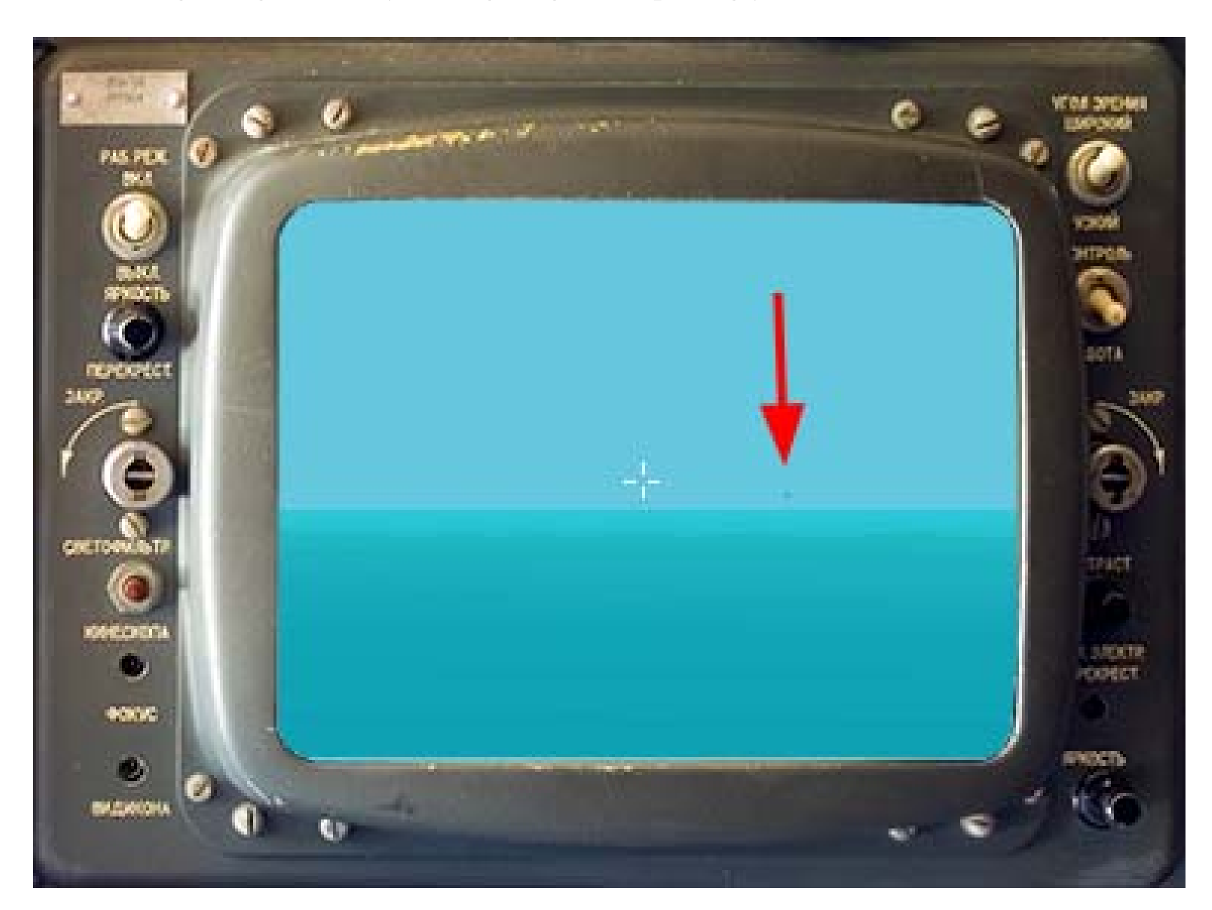


Due to the physical size limitation of the HARM missile head, its wideband quad spiral antenna cannot be used against the P-18 target acquisition radar due to its long wavelength.

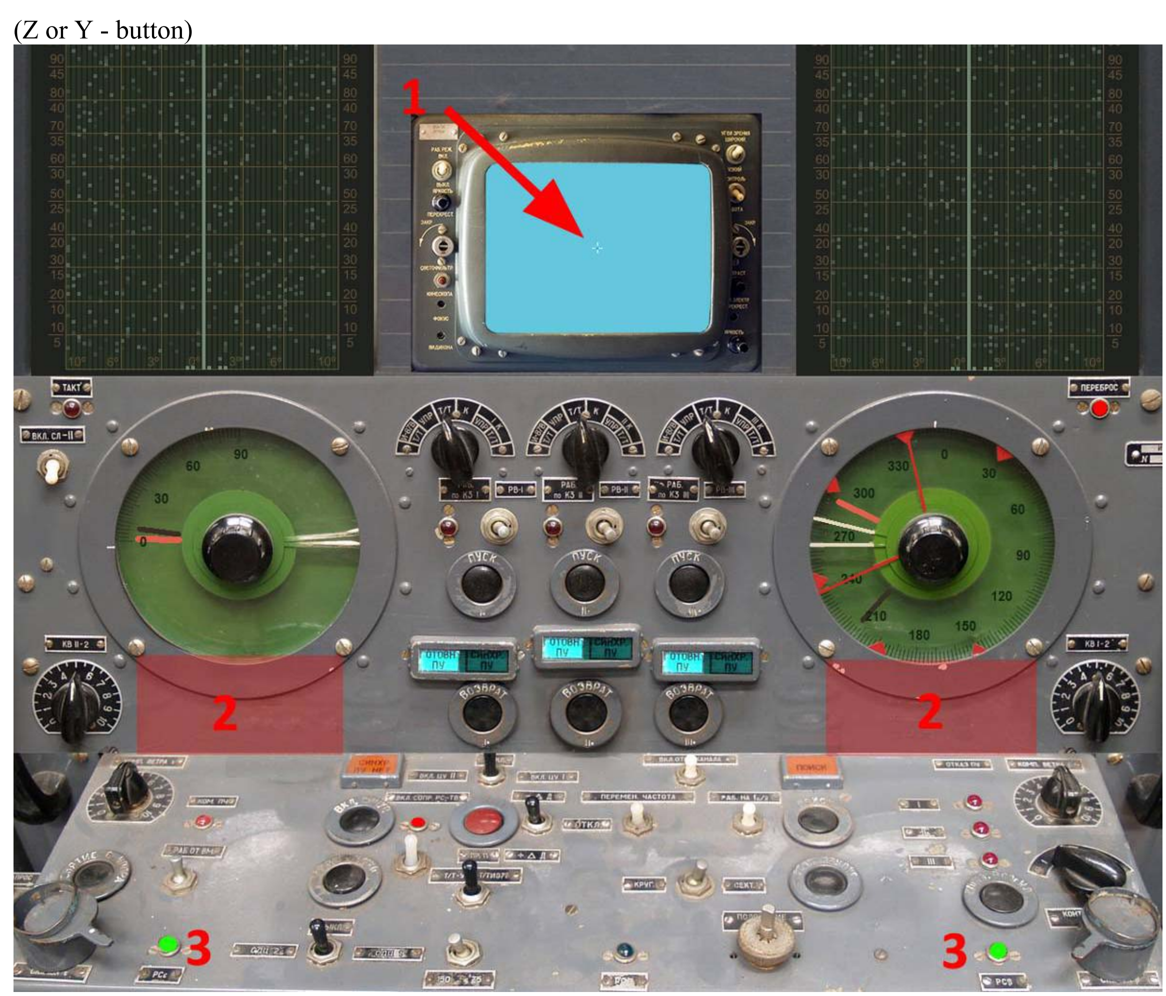


Rotate the SNR towards the target in azimuth using the P-18 ПЕРЕБРОС (throwing over), as described in page 29, and scan slowly upwards, until the target is seen.

Discovering a target visually at long range is surprisingly difficult



(Z or Y - button)



Aim the PV towards the target (as described in page 21). If its moved into the cross hair (1), we can click with the right mouse button in any of the red areas (2), and the system* goes into automatic tracking in elevation and azimuth. The PCε, PCβ (target is in automatic tracking in elevation, azimuth) lamps are illuminated (3).
By reading off the target altitude from the plotting board (described in page 17), and distance from the P-18 display (described in page 18), the optimal firing time can be determined manually, by using the table below.

Target altitude between	Maximum firing range
500m – 1km	15km
1 – 5km	25km
5 – 15km	30km
15 – 25km	40km

Limitations of the optical guidance:

- It can be used daylight only, in with good visibility
- maximum target speed is 640m/s (Mach 2)
- minimum target altitude is 500m
- maximum altitude is limited to 25km
- maximum range is limited to 40km